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Field investigation of terminals in a dial central office.

A Twin-Channel Single-Sideband Radio Transmitter

By K. L. KING
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THE advantages of single-sideband transmission, and the receiver designed for this system, have already been the subject of several articles in the RECORD.* To carry on studies of this type of short-wave transmission between England and the United States, an experimental single-sideband transmitter was built, and installed in England in 1934. A somewhat modified design was made later. Two transmitters of this latter type are now installed at Lawrenceville, New Jersey, for transatlantic service, and one is used at each end of the San Francisco-Honolulu circuit. To take advantage of the experience gained, further modifications have recently been made in the design of the transmitter, which has been changed also so that it may be used for either single or double-sideband transmission. Several of these new equipments, known as the D-156000 radio transmitter, are now in service at Lawrenceville, Ocean Gate, Panama, Buenos Aires, and Switzerland and others are projected.

One of the interesting features of this new single-sideband transmitter is that it can transmit simultaneously two independent single-sideband signals. An accompanying carrier is transmitted at reduced amplitude so that the major part of the output is in the two sidebands. When the two sidebands are used as two separate channels, the voice-frequency bands extend from 250 to 3000 cycles, but one of them is translated to the band from 2250 to 5000 cycles by a modulator and filter system in the terminal equipment preceding the transmitter. Thus the two telephone channels are separated by an interval of 2500 cycles into which the major products of distortion fall. This results in substantial reduction of crosstalk between channels.

Although this transmitter provides two channels for single-sideband transmission with voice bands 2750 cycles wide, it will also provide a

*May, 1936, p. 303; Aug., 1936, p. 405; Nov., 1939, p. 84.

single channel for a voice band from 100 to 6000 cycles wide. This wide, high-quality band may be transmitted as either single or double sideband. The change from single to double sideband may be made either locally or by remote control, since the operation of a single relay is all that is required to change from one type of transmission to the other. This feature is of particular advantage when the transmitter is to be used for service to several points, some of which are not equipped for single-sideband reception.

A block schematic of the transmitter is shown in Figure 1. Three modulating steps are used. The first two conversion frequencies, of 125 and 2500 kc, are both derived from a single 625-kc oscillator—the 125 kc through a multivibrator, and the 2500 kc through a harmonic generator. For two-channel single-sideband transmission, the two voice bands are supplied to modulators 1A and 1B together with the 125-kc conversion frequency.

These units are balanced modulators, and thus the output of each consists only of the two sidebands of 125 kc, the carrier itself being suppressed by the balanced circuit. The two filters following the modulators, however, select opposite sidebands—filter A selecting the upper, and filter B, the lower. The two single sidebands passed by these filters, combined with a reduced carrier, form the input to the second modulator, which uses the 2500-kc conversion frequency. The upper sideband of this modulation is

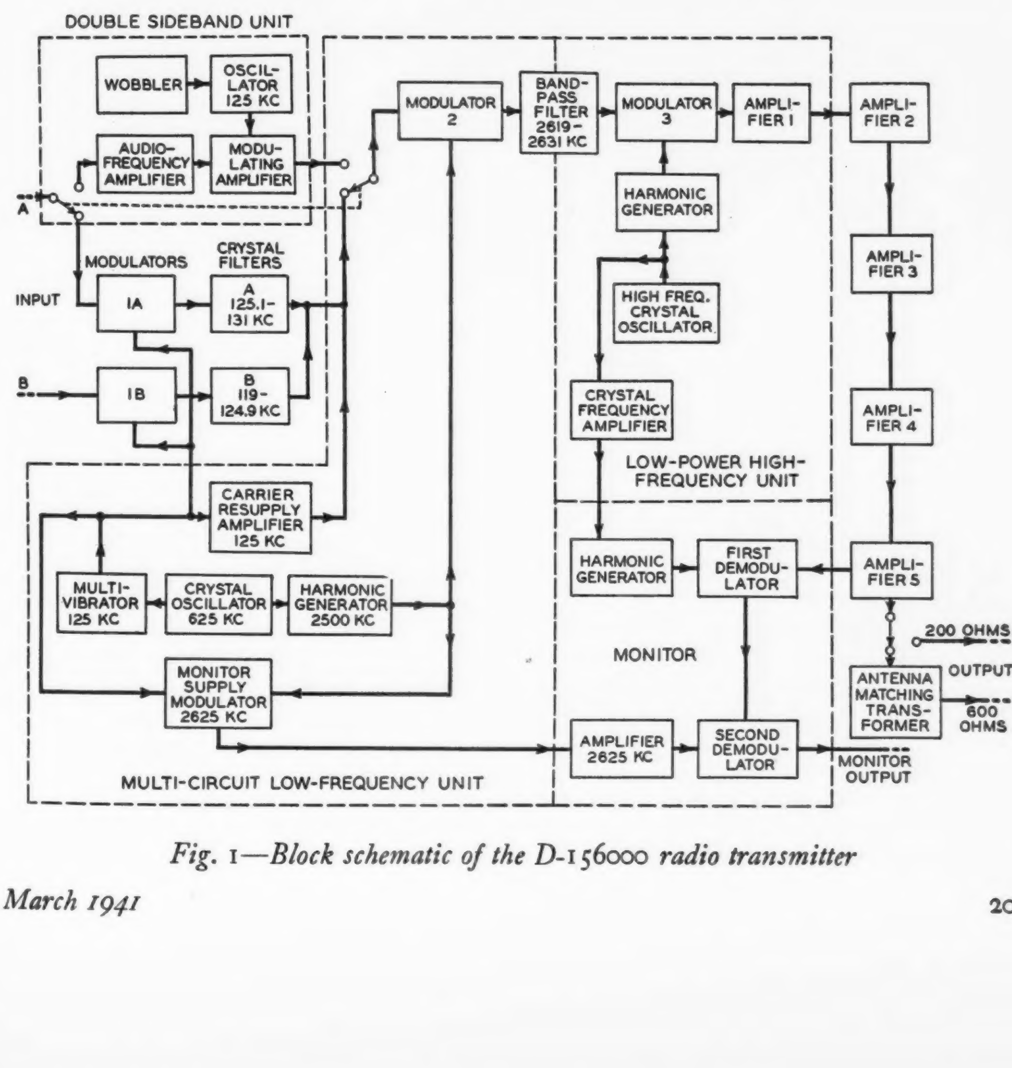


Fig. 1—Block schematic of the D-156000 radio transmitter

selected by the following filter, and passed to the third modulator.

The transmitter is arranged for operating on any of six predetermined frequencies between 4½ and twenty-two megacycles, and the third conversion frequency must be chosen to give the desired final frequency. The

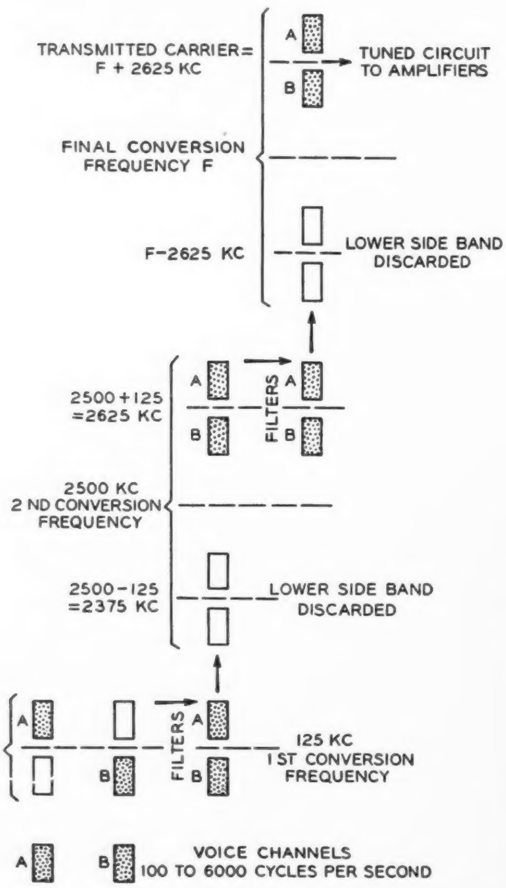


Fig. 2—Frequency diagram for the single-sideband transmitter

oscillator is arranged for control by any one of six quartz plates, and these, as well as the proper tuned circuits for the associated harmonic generator, are selected from the front of the panel. Five amplifier stages follow the third modulator, and give the transmitter an output of 2 kw for the envelope peak. As used at Lawrenceville, the transmitter drives a water-cooled amplifier with an envelope peak output of 60 kw.

A frequency diagram of the transmitter is given in Figure 2. It shows the various conversion frequencies and the relative positions of the sidebands. Sidebands transmitted are shown cross-hatched, while those discarded are shown clear.

When used for double-sideband transmission, a separate first oscillator and modulator are employed. This part of the circuit is shown at the upper left of Figure 1. From the second modulator on, it is the same for both types of transmission.

To give the operators of the transmitter an opportunity to measure distortion when using single-sideband transmission, a built-in monitor is provided. A small amount of the out-

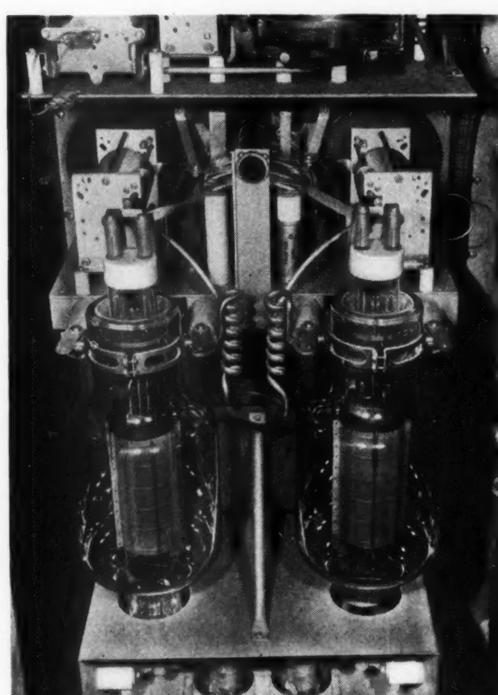


Fig. 3—Close-up of fifth amplifier panel showing switch that is used for cutting in additional capacitance

put of the transmitter is fed to a two-stage demodulator. The first stage is supplied with the third conversion frequency through a separate harmonic generator, while the final stage is supplied with a conversion frequency of 2625 kc, which is derived by combining the first and second conversion frequencies of the transmitter in the monitor-supply modulator.

The transmitter consists of three panels shown from the front in the photograph at the head of this article, and from the rear in Figure 4. The right-hand bay in Figure 4 includes most of the power-supply equipment, while the left-hand bay includes all the equipment up to the filter between the second and third modulator. Rectifiers for the filament supply of the medium-power amplifiers are also on this bay. The middle panel includes the third modulator with its oscillator and harmonic generator, the five subsequent amplifiers with their tuned circuits, and the monitoring equipment. This latter equipment is on the lowest panel, evident in Figure 4, while on the panel immediately above it is the oscillator and its associated equipment, the third modulator, and the first of the following amplifiers. The next three panels, equal in size, include the second, third, and fourth amplifiers with their tuned circuits. Above them is the fifth amplifier and its tuned circuit.

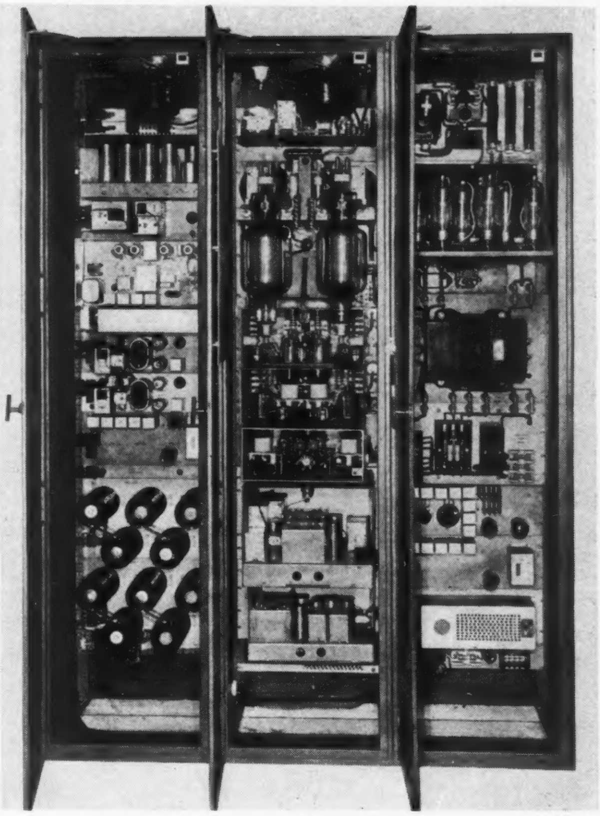


Fig. 4—Rear view of the D-156000 transmitter

Since the frequencies are all fixed up to the third modulator, no operating adjustments are required. Beyond this point, however, any of six frequencies may be employed, and switching arrangements are provided to select the proper oscillator crystal, and the pretuned circuits in the harmonic generator, the third modulator, and the first two amplifiers. In amplifier stages 3, 4, and 5, the variable inductances employ a rider wheel to short-circuit the end turns of a rotating coil, similar to those described in connection with the 16A radio transmitter.* The two inductances for each stage are geared together and driven by a single handle. The number of turns of inductance in use is shown by indicators visible from the front. Because of the larger currents encountered in amplifier 5, the inductance range is smaller, and additional capacitance must be added for the lower carrier frequencies. This is done by a cam-operated switch.

*RECORD, *Sept.*, 1935, *p.* 17.

Handling DSA Traffic at Toll Boards

By D. F. JOHNSTON
Switching Development Department

A SUBSCRIBER in a dial area has access to both an outward toll operator and a "DSA" operator.* The latter is usually reached by dialing zero. She assists in completing calls that for some reason or other the subscriber has not been able to complete; she may handle directly the shorter distance toll calls; and she may take also reports of trouble conditions, fires, or other emergencies. She also handles calls from any manual lines in the area, and in addition is connected to the subscriber lines over intercepting trunks when a line has been dialed on which no service is available, either because it is an unassigned number or because there is trouble on the line. The outward toll operator, on the other hand, sets up all outgoing toll calls except those shorter ones handled by the DSA operator, and is reached by dialing some number such as 110, which is the number used in the step-by-step system. These two types of operators have generally been located at different switchboards, and often in different buildings. The toll operators are at the toll office, and the "DSA" operators at one or more of the local offices. Studies have shown that in some cases more economical handling of calls would be brought about if arrangements were made to enable the toll operators to handle DSA calls as well as toll calls. This would do away with the DSA boards, and obtain the economies of combined service.

To provide DSA service at a toll board, however, certain modifications are required, and the necessary circuit arrangements have been developed by the Laboratories for the

*Dial System "A" operator.

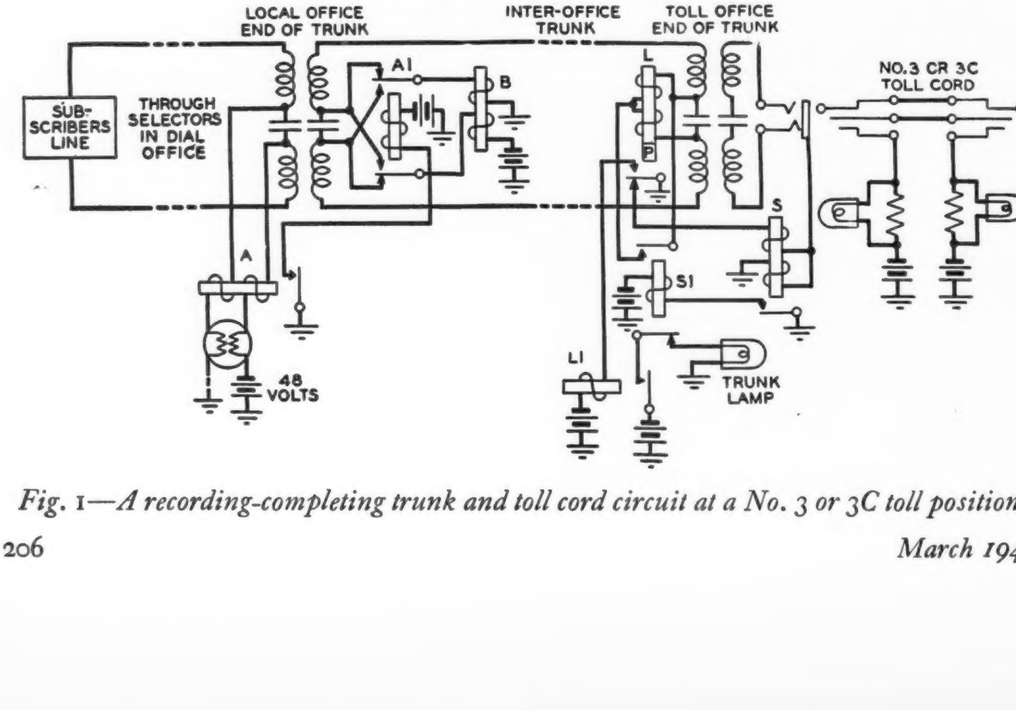


Fig. 1—A recording-completing trunk and toll cord circuit at a No. 3 or 3C toll position

Nos. 1, 3, and 3C toll boards. Since it is desirable to keep the transmission losses in a toll system as low as possible, no apparatus is connected to the talking leads of the toll cords at the switchboard except at No. 1 toll positions, where a high-impedance bridge is used at the line end for receiving a-c signals, and another high-impedance bridge at the office end for receiving d-c signals. The equipment for supplying talking battery to subscribers is placed in the local office end of the recording completing trunks, over which the subscribers reach the toll office. The circuit arrangement of such a trunk, and a toll cord at a No. 3 or 3C position, is shown in simplified form in Figure 1. At the DSA boards, on the other hand, this battery supply is placed in the cord circuit as shown in Figure 2. When DSA service is to be given at toll positions, therefore, the calls must be routed to the board over a recording completing trunk, so that battery supply will be available.

In a dial area there are commonly a number of manual lines for subscribers who for some such reason as physical disability need manual operation. Such lines are normally terminated at DSA positions, where the battery is supplied from the cord circuits. When toll positions are used for DSA service, these lines must be brought to the toll board, and a battery supply must be provided in the line circuit. Where there are a large number of manual lines, the cost of equipping all of them with the necessary battery-supply circuit may make the use of toll positions uneconomical for this purpose.

Another change required in giving DSA service at the toll board is the provision of intercepting trunks. These also must supply the features which at regular DSA positions would be supplied from the intercepting cords.

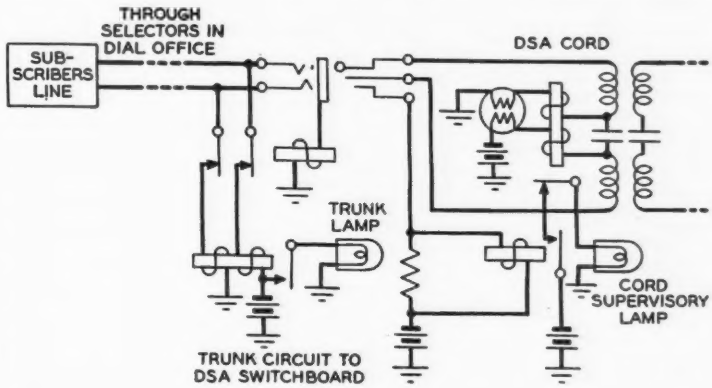


Fig. 2—A subscriber's line and DSA cord circuit at a DSA position showing location of battery supply

In addition to these changes required to provide battery supply, others are needed to permit proper signalling and dialing. DSA cords are designed to use d-c supervisory signals, and to dial over either end. The Nos. 3 and 3C toll cords also have these provisions, and thus no changes in these respects are required for them. The No. 1 toll cords, however, are not arranged to receive d-c signals on the toll end. It was necessary, therefore, to add a d-c signalling bridge at this end also, and to insert condensers in the talking conductors to separate the two d-c bridges. Then to avoid the severe shunting effect of the added bridge on the a-c bridge, the connections of the a-c bridge were arranged so that there would be only one condenser in the path to the supervisory relay.

To provide dialing at both ends of the No. 1 cord, considerable modifica-

tion was required, since the dial circuit had to be changed, and a new position circuit added. The cord, when changed, differed so much from the regular cord that it was given a distinctive designation, and is now known as the type-A toll cord.

Besides these changes, consideration also had to be given to the matter of ringing. DSA positions are equipped to ring on individual lines, two-party lines, or four-party lines either semi or full-selective. All these types of ringing are not required at toll positions, since ordinarily there is no need for the operator to ring the subscriber back on the line over which the subscriber calls. On delayed calls, where the subscriber must be recalled, the toll operator dials the subscriber's number, and ringing is supplied from the dial-office equipment. A toll operator has need to ring back on an answering cord only to coin stations and PBX's, and thus the toll positions are equipped for ringing only on single-party lines, no provision being made for ringing over the various types of multi-party lines. So far as normal service is concerned, therefore, the ringing facilities at a toll board, although less extensive than at the DSA positions, would be entirely sufficient.

There are times on rare occasions, however, when the operator at a DSA position could render greater service if she could ring back on any type of line. Suppose, for example, that a subscriber dials "operator" to report that his house is on fire, and then before giving his number, abandons the call either by hanging up or by leaving his receiver off the hook. The operator has no way of knowing the number because she is connected to the line over a trunk that might be used by any line in the area, but since her cord is connected to the trunk, she could call the subscriber back if she had the proper ringing facilities. If it were a two or four-party line, and the

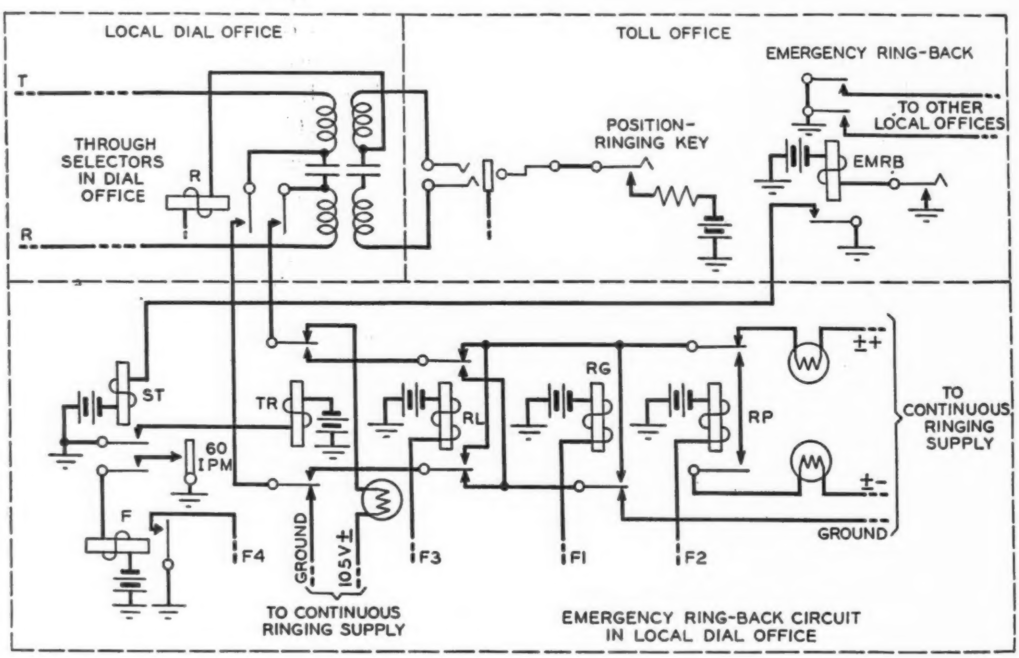


Fig. 3—Simplified schematic of emergency ring-back circuit at a toll position

receiver had been left off the hook, the operator could ring the other parties on the line and determine the number by a process of elimination. The ringing facilities at the regular DSA boards permit this to be done. The operator does not, of course, know the type of line, but she applies one type of ringing after another until a response is obtained.

To make this emergency ring-back available at toll positions used for DSA service, a new emergency ring-back circuit has been developed. The toll position is normally equipped with a ringing key that operates a ringing relay in the trunk circuit, and when the key is operated, the relay connects ringing voltage to one side of the line and ground to the other. The new circuit adds an emergency ring-back key that operates relays, first to transfer the leads from the ringing relay to an emergency ringing supply, and then to apply, in successive half-second intervals, the various types of ringing to the line. In this way all the parties on the line, regardless of type, will hear ringing at least once every 2½ seconds. Although no attempt is made to give code ringing, it is felt that the attention of all subscribers will be attracted by the unusual timing of the emergency ringing, and that they will answer their telephones. The circuit is shown in simplified form in Figure 3.

The ST relay, which is operated by the emergency ring-back relay, operates the TR relay to transfer the leads from the ringing relay to the emergency ringing circuit, and also makes a connection to an interrupter circuit, which alternately applies open-circuit and ground at half-second intervals to relay F. The leads from the TR relay, over which the emergency ringing is to be sent, pass through contacts on relays RL, RG, and RP which when operated singly or in various combinations transmit all the needed types of signals from the three ringing leads marked ± −, ± +, and ground. Relays RL, RG, and RP are operated in rotation in various combinations by a

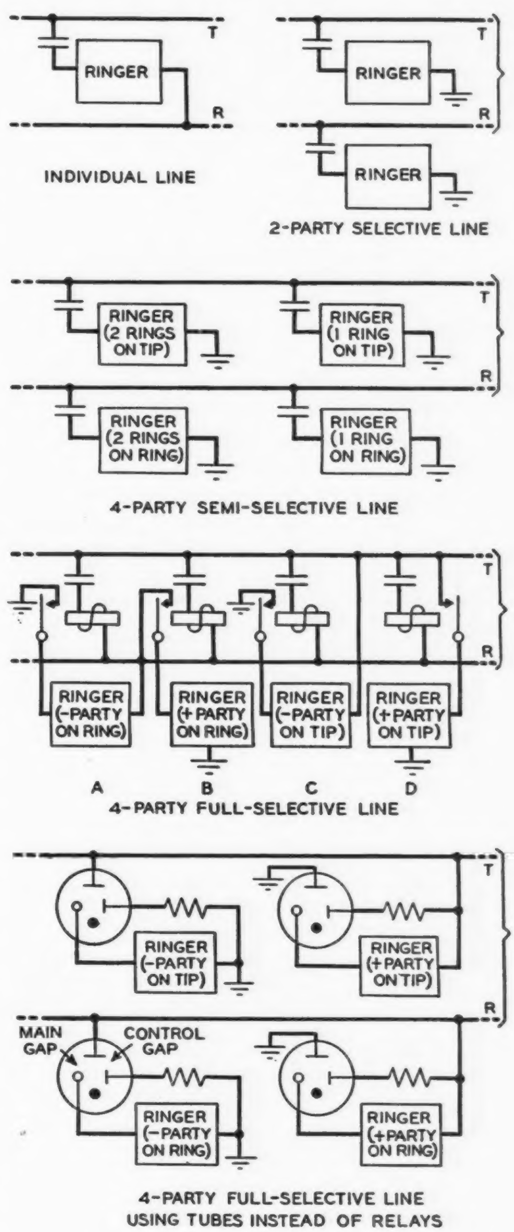


Fig. 4—Various types of ringing circuits over which the emergency ring-back circuit has been designed to operate

group of four relays associated with leads F1, F2, F3, and F4. As a result of the action of the interrupter circuit, which alternately grounds lead F4 and removes ground from it through relay F, these four relays put ground on leads F1, F2, and F3 to operate relays RG, RP, and RL, respectively, and thus to send out ringing that is changed in type every half second for as long as the emergency ring-back key is held operated. The arrangements of the ringers on various types of lines are shown in Figure 4.

Relays ST, TR, RL, RG, RP, F and those associated with leads F1, F2, F3, and F4 are installed in each of the local dial offices, one set being required for each office. The emergency ring-back relay is in the toll office, and is operated by an emergency ring-back key at each position. The operation of this key and relay operates the ST relays in all the local offices and thus transfers all ringing to the emergency condition. This does not interfere with the normal ringing being done at other positions of the toll board because all of the combinations but one provide individual line ringing.

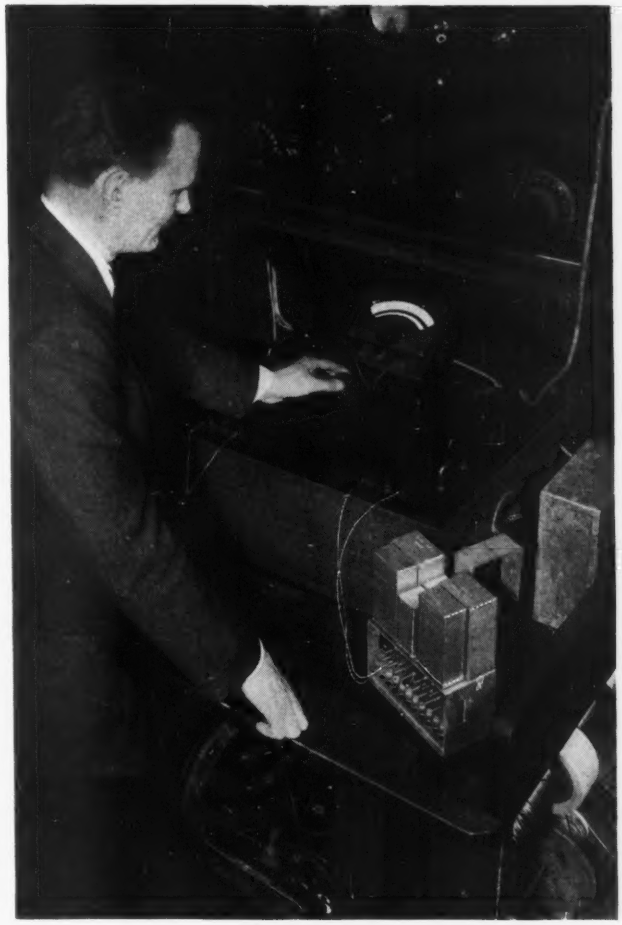
This emergency ring-back circuit, as already noted, is not essential to the provision of normal DSA service at toll positions. It has been developed by the Laboratories to make available facilities for giving this added service whenever local conditions make it seem advisable. The other provisions, however, are always needed, and with their adoption there has been a rapid trend toward the consolidation of the DSA service with the toll service.

451A-1 Radio Transmitter

Developed by Bell Telephone Laboratories, this new radio transmitter is intended for applications where power in excess of 250 watts is not contemplated. It effectively covers the broadcast, police, and emergency-communication services in the frequency range from 550 to 2750 kilocycles. Like the 1-kw transmitter, described in the Record for September, 1931, and the frequency-modulation transmitter described in September, 1940, this new transmitter has all its electrical components assembled on a central unit, around which the enclosing cabinet is placed. All the important controls are behind the two narrow doors at the sides of the front. This construction gives ease of assembly, maintenance, and control without detracting from safety of operation or appearance.

Autotransformer for Emergency Repair of Open-Wire Carrier Circuits

By H. H. FELDER
Toll Transmission Development



WHEN unusually severe sleet storms and high winds destroy sections of open-wire lines, the telephone companies are confronted with a real problem in maintaining the continuity of telephone service. Considerable time may be required to put the lines back into their normal condition, and to avoid a lengthy interruption of telephone service it has been customary to bridge the break in the lines with twisted pairs, which may be placed on temporary supports, tied to trees, or laid along the ground. The wire used for restoring toll lines in this manner is known as HC drop wire. It is 14-gauge, twisted pair, rubber insulated, and carries weatherproofed braid for mechanical and sunlight protection. It can easily be stored in a central location, and after use can be reclaimed, and returned to the storehouse for future use.

In recent years there has been a considerable increase in the use of carrier systems on open-wire lines, and with the introduction of the new J-carrier system* in a frequency band above the type-C system, as many as fifteen two-way telephone circuits in addition to the usual voice-frequency circuit may be provided by a single pair of wires. Under such conditions, it becomes even more desirable to restore service promptly, but unfortunately the transmission characteristics of the HC drop wire are not such that it can be connected directly to open-wire lines and permit satisfactory communication over the wide frequency range used by the C and J-carrier systems. Its impedance differs so greatly from open-wire impedance that severe reflections would occur at the junctions. The most serious effect would be a prohibitive increase in reflection crosstalk† in parallel carrier systems on the same pole line, by

*Record, *April*, 1940, *p.* 226.

†Record, *Nov.*, 1934, *p.* 66.

the conversion of near-end to far-end crosstalk. Moreover, the loss due to impedance mismatch at the junctions combines with the attenuation loss of the drop wire to substantially increase the insertion loss.

To secure the maximum advantage of this simple method of line repair

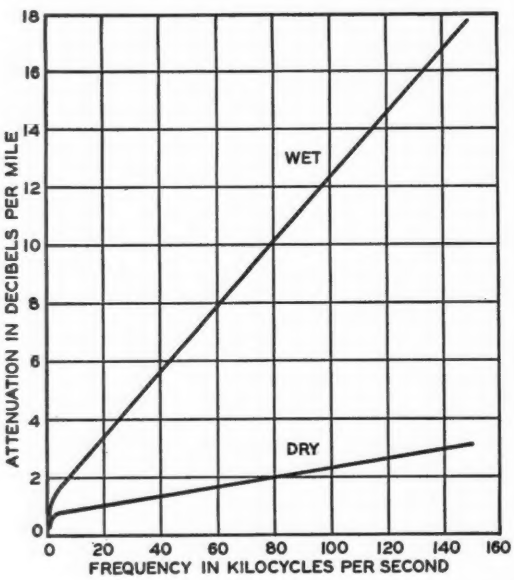


Fig. 1—Attenuation characteristics of HC drop wire

for carrier systems, therefore, an autotransformer has been developed for use at the junctions of open wire and HC drop wire. This device greatly reduces the junction reflections so that the reflection crosstalk effects become tolerable for all lengths of drop wire that are satisfactory as regards insertion loss. The component of the insertion loss due to junction reflections, moreover, is practically eliminated, leaving only the attenuation loss of the drop wire plus the small transformer loss. These very desirable improvements in carrier transmission performance are obtained with some, but usually tolerable, impairment in the other services routed over the open-wire lines. This impairment includes the restriction of direct-current telegraph service to one grounded circuit per open-wire pair.

The curves of Figure 1 show the large variation in the attenuation of HC drop wire with frequency and moisture conditions. This variation is due to the moisture absorption properties of the weatherproofed braid, which is included for mechanical protection. The data on Figure 1 are of special concern in the line repair method under consideration because the lengths of autotransformer-terminated drop wire that can be allowed in an open-wire carrier line are basically determined by the losses at high carrier frequencies, in relation to the available reserve amplification in the carrier repeaters.

The characteristic impedance of HC drop wire is shown in Figure 2. Over the frequency range of the J-carrier system, the reactance is essentially zero, and the resistance is practically constant with frequency, although it varies between about 150 and 80 ohms depending on the weather. The characteristics of an open-wire line are similar in form; that is, it has essentially zero reactance and a flat resistance, but the resistance—which varies with the type of line rather than with weather conditions—is between 500 and 650 ohms. The impedance-matching transformer must thus increase the impedance of the HC drop wire to make it approximately the same as that of an open-wire line. An autotransformer is employed, and to enable it to meet a variety of conditions, it is designed with a compromise impedance ratio.

To permit d-c tests to be made on the open-wire line after the drop wire has been installed, a condenser is inserted at the midpoint of the auto-

transformer. This condenser resonates with the inductances of the low-impedance and high-impedance sections of the transformer winding to form two cut-off frequencies which will vary in value depending on the size of the condenser. Between these two frequencies is a suppression band, above and below which are pass-bands. Carrier, voice, and 135-cycle frequencies fall in the upper pass-band, but the 20-cycle signalling is transmitted in the lower pass-band.

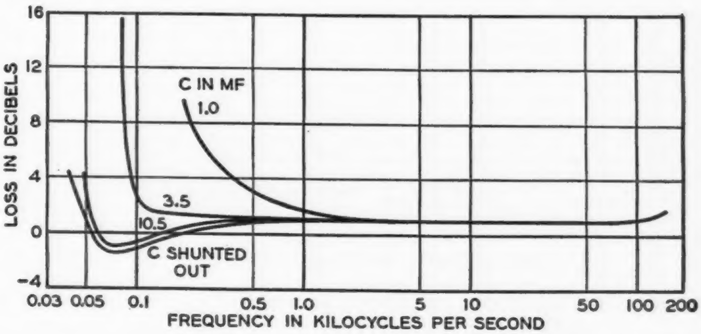


Fig. 3—Insertion-loss characteristics of two 24A autotransformers with different values of capacitance

To meet the various conditions encountered, three values of capacitance are provided. With a 3.5 mf capacitance the lower boundary of the upper pass-band is below 135 cycles and the autotransformer is satisfactory for 135-cycle and voice-frequency signalling as well as for the voice and carrier-frequency telephone channels. It is relatively unsatisfactory for 20-cycle signalling, however. In the lower pass-band where 20-cycle signalling occurs, the autotransformer functions as a simple series impedance in the line and the condenser is shunted across the line at one end of this impedance. For efficient 20-cycle signalling, it is essential that the shunt impedance be increased and therefore 1 mf is used. This raises the lower boundary of the upper pass-band and slightly impairs transmission in the voice-frequency channel. For this reason 1 mf is used only when 20-cycle signalling is employed. When the circuit is used for program transmission it would be desirable to short-circuit the condenser so as to eliminate the suppression band and allow the low program frequencies to be satis-

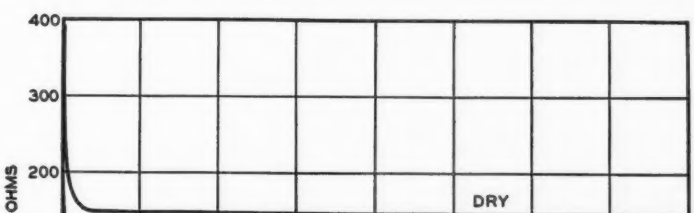


Fig. 2—Characteristic impedance of HC drop wire: resistance component, above, and reactance component, below

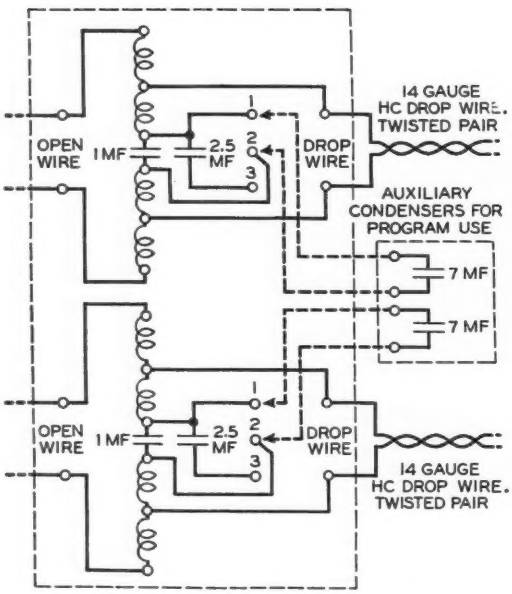


Fig. 4—Circuit diagram of the 24A autotransformer for open-wire circuits

factorily transmitted. This would make d-c testing impossible, however, and so when the ability to make d-c tests cannot be dispensed with, or when a recent form of program reversal circuit is employed, a 10.5 mf condenser is employed, which is large enough to give program transmission only slightly poorer than when the condenser is short-circuited. The insertion-loss characteristics for these various arrangements are shown in Figure 3. The losses shown are for two autotransformers with zero length of drop wire; the loss that occurs in the drop wire itself must be added to obtain the overall loss.

These various capacitances are secured by providing a 1-mf condenser connected at the midpoint of the transformer, and 2.5 and 7-mf condensers that may be connected in parallel with it as required. The 2.5-mf condenser forms part of the transformer unit, but the 7-mf condenser is furnished as a separate element, and is installed only when it is required.

The complete transformer assembly, known as the 24A autotransformer, consists of two autotransformers each with a 1 and a 2.5-mf condenser arranged in a single metal container. The circuit diagram is shown in Figure 4, where the leads to the 7-mf condensers are dotted lines to indicate an optional arrangement. By strapping terminals 2 and 3 together, the capacitance is made 3.5 mf, and when in addition the 7-mf condenser is connected to terminals 1 and 2, it becomes 10.5 mf. The physical arrangement of the apparatus is shown in Figure 8 and in the photograph at the head of this article. The two transformers and four condensers are mounted on a panel through which

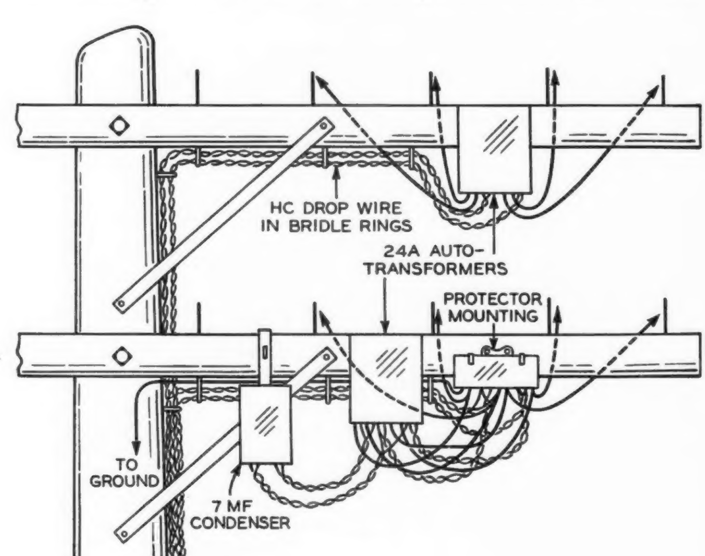


Fig. 5—Method of mounting 24A autotransformers on cross-arms, with and without protectors

their terminals project into the terminal compartment. A terminal strip in this compartment provides seven main terminals for each of the two transformer units. A strap fastened to the bottom of the terminal compartment is used to suspend the unit from a crossarm, and a cover slips over the assembly and is held to the bottom of the terminal compartment by a clamping screw. When installed on a crossarm, it appears as shown in Figure 5. Here a 24A autotransformer alone is installed on the upper arm. This arrangement is used where program circuits are not involved and where because of seasonal factors, protection from lightning or other high voltages is not required. The arrangement on the lower arm in Figure 5 shows suitable locations for the installation of the 7-mf condenser, and the protector mounting when required.

The improvement in reflection coefficient to be expected when autotransformers are used is indicated in Figure 6. The upper curve shows the reflection coefficient at one end of an 0.8-mile section of drop wire inserted in an open-wire line without autotransformers, while the lower curve shows the results when autotransformers are employed at the two junctions. It will be noticed that with transformers the coefficient is under 0.10 over practically the entire frequency range, increasing somewhat only at very low frequencies. This increase arises partly because the impedance ratio of the transformer is far from ideal at these frequencies and partly because the transformer and condensers contribute impedance distortion. Under wet conditions, the coefficient may rise to about .20 in the carrier range, but a lower value will be resumed as the drop wire dries out.

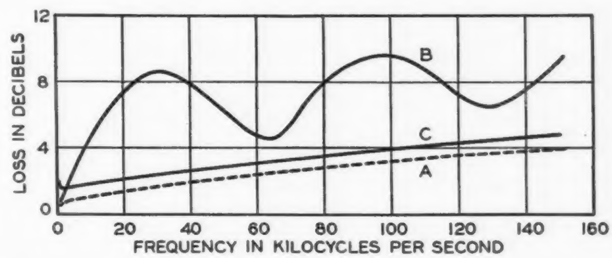


Fig. 7—Improvement in insertion loss when 24A autotransformers are employed

The improvement in insertion loss secured by the autotransformer under dry conditions is shown in Figure 7. Curve B shows the loss when 0.8 mile of drop-wire is connected between open-wire lines without transformers, and curve C, when transformers are employed. Curve A shows the characteristic loss of the drop wire by itself, and serves as a basis of comparison for

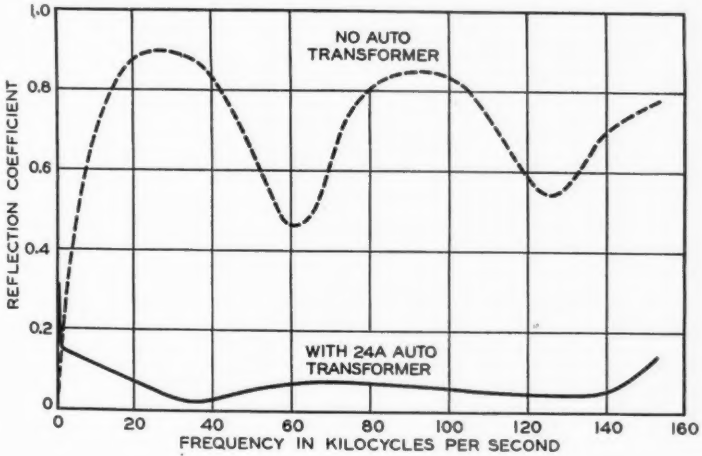
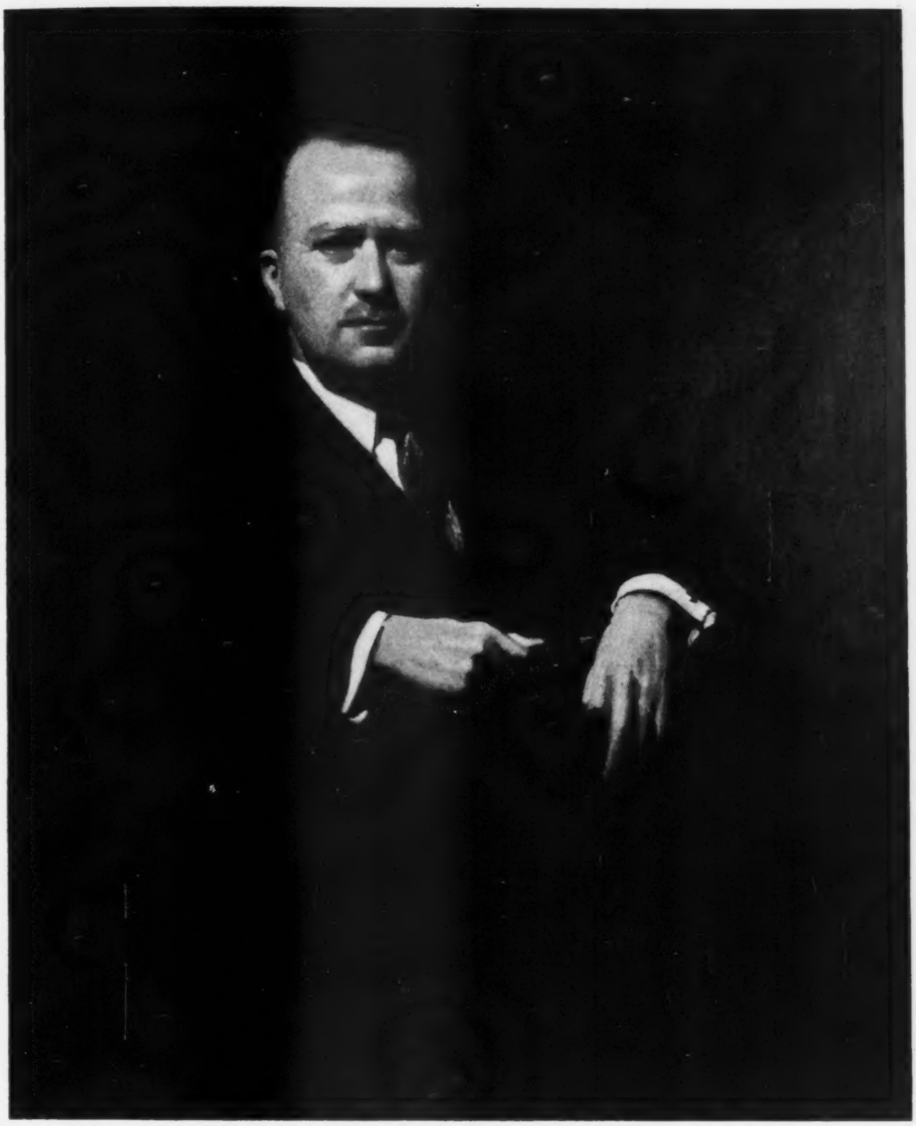


Fig. 6—Improvement in reflection coefficient when 24A autotransformers are employed

the other two curves. The data apply for "dry" drop wire. With "wet" or partially wet drop wire, the losses would be greater, so that even under favorable conditions with respect to reserve amplification, it will seldom be practicable to use more than about two miles of HC drop wire in an "average" repeater section in type-C or J carrier-frequency systems.

When installing the drop wires on a pair-for-pair basis, it is desirable to have some separation between them to minimize possible crosstalk. It has been found, however, that if the wires are tied together only at the supports, and allowed to hang loosely between supports, the crosstalk between pairs will be small compared to that resulting from the junction reflections and from local disruptions in the open-wire transposition systems.

Fig. 8—A cover slips over the autotransformer unit, with the rear side between it and the suspension bracket



President Walter S. Gifford

This portrait, painted by Frank O. Salisbury in 1929, hangs in the Directors' Room of the American Telephone and Telegraph Company at 195 Broadway. On the walls of this room are portraits of T. N. Vail and H. B. Thayer, former presidents of that Company. Mr. Gifford's annual report to the stockholders for 1940 has recently been issued; and excerpts from it are reprinted in the following pages

Excerpts from the Annual Report of the American Telephone and Telegraph Company

The management of the American Telephone and Telegraph Company presents herewith an account of its stewardship for the year 1940 for the information of stockholders, employees, telephone users, and the entire American people who have entrusted to private enterprise the responsibility for carrying on this essential national service

NATIONAL defense considerations greatly influenced the course of events in 1940 in the American Telephone and Telegraph Company and its Associated Companies in the Bell System. Much pending construction was advanced ahead of schedule. Prudent measures were taken to safeguard telephone facilities. Reserve power equipment was installed or ordered at all important telephone central offices which did not already have it, so as to assure continuity of power supply under all conditions. The establishment of alternate toll routes between important points, which has already done so much to improve the dependability of toll and long distance service, was given further impetus. . . . Where the need lay in the future, rather than in the present, steps were taken to increase the available number of telephone circuits along important routes and to make sure of adequate circuits, equipment and personnel at points where there might be unusual service demands. Concurrently, there was a general expansion of activity throughout the System to meet the increasing demand for service, and to be ready for whatever additional demands the future may bring.

The Bell System's manufacturing organization and its laboratories—the Western Electric Company, Incorporated and the Bell Telephone Laboratories, Incorporated—were busy supplying special needs of the military services besides caring for the increased needs of the telephone operating companies.

The nation-wide universal telephone service needed for defense as well as for everyday business and social life is made possible by the interconnection of 17,484,000 Bell System telephones with more than 4,375,000 telephones of some 6,400 connecting telephone companies and more than 60,000 rural or farmer lines. The splendid coöperation between independently owned telephone companies and lines and the Bell System is an essential factor in enabling anyone anywhere to pick up a telephone and talk to anyone else, anywhere else, clearly and quickly. Moreover, this coöperation is invaluable in marshalling the resources of the entire telephone industry in the interest of national defense.

Telephones and Conversations

The number of Bell System telephones in service reached a new high of 17,484,000. . . . The average number of telephone conversations per day in 1940 was 79,303,000, or over 5,500,000 more per day than in 1939.

Telephone Plant

In 1940, the System expenditures for new plant construction, not including plant and material which were taken out of service and re-used, amounted to $290,000,000. Total gross additions to telephone plant, which include re-used plant and material, amounted to $381,393,000 and retirements to $224,229,000, resulting in a net increase of $157,164,000, or 3.4 per cent. . . . The investment in telephone plant at the end of the year was $4,747,674,000, against which there

were depreciation and amortization reserves of $1,360,896,000, or 28.7 per cent.

Employees

The employees of the Bell System, including the Western Electric Company and the Bell Telephone Laboratories, numbered 322,000 at the end of 1940, an increase of 24,900 over the end of 1939. Of the total employees, 147,500 were men. About 57,000 of these were between the ages of 21 and 35, inclusive, and were registered under the Selective Training and Service Act of 1940.

Revenues

In 1940, the Bell System gross operating revenue was $1,174,322,000, an increase of 6 per cent or $67,134,000 over 1939. As a result of tax increases, net operating income failed to increase correspondingly and was only 1.6 per cent, or $3,531,000, more than in 1939.

The American Telephone and Telegraph Company earned $10.08 per share of stock in 1940, as compared with $9.24 per share in 1939. The total net income of the System applicable to American Telephone and Telegraph Company stock was $11.26 per share, as compared with $10.18 in 1939.

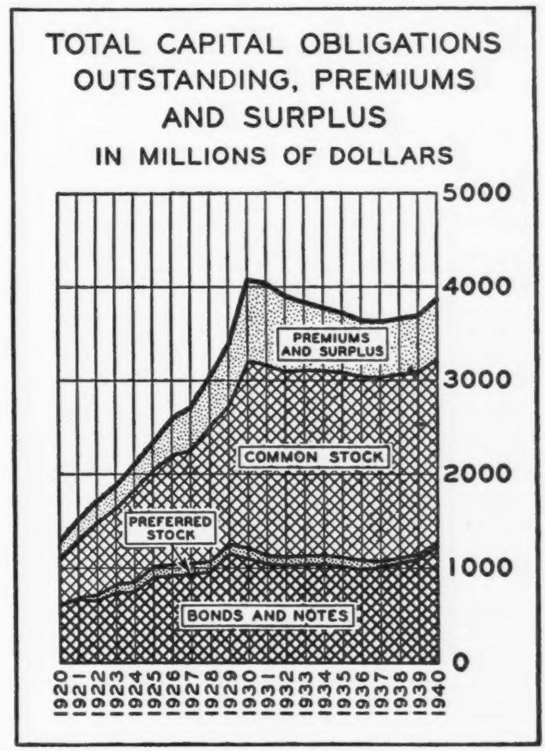
Stockholders

At the end of 1940, there were 630,900 stockholders of record of the American Telephone and Telegraph Company. . . . The average number of shares held per stockholder at the end of 1940 was 30. . . . Approximately one-fifth of the Bell System employees owned stock in the Company. No stockholder held as much as 1 per cent of the total stock.

Service

The personnel continued to make telephone service friendly and helpful as well as technically efficient. This has, in fact, become a way of life for telephone workers. Moreover, telephone people have to give service very frequently under onerous and unusual conditions, both in central offices and outside. To appreciate this, it is only necessary to recall what they confront in storms, disasters and other emergencies. No material reward by itself can secure the services rendered by telephone employees under these conditions.

The number of dial telephones in service increased by 1,250,000 in 1940. About 60 per cent of Bell System telephones were dial at the end of the year, as compared with 56 per cent at the end of 1939. The crossbar dial system . . . was installed in several additional cities with satisfactory results. Some 350,000 telephones are now served by crossbar equipment. During the year, more than 400 small



Bell System central offices were converted to dial operation, most of these conversions being from magneto service.

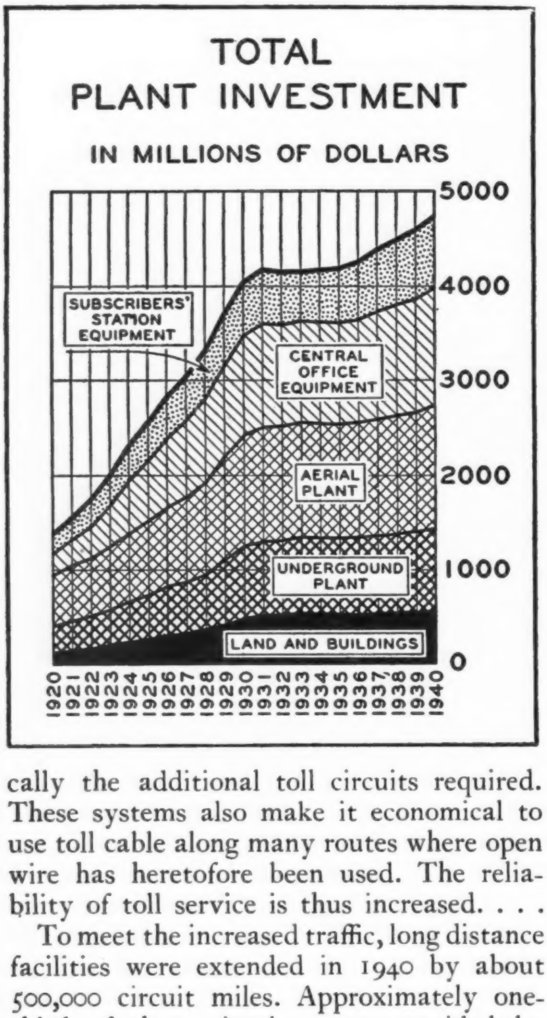
Progress was made in the dialing of toll calls by operators. Under this method of operation . . . the operator, instead of relaying the call to another operator at the distant central office, dials the called party at the distant point directly over the toll line. About 15 per cent of all toll messages were handled in 1940 in this manner, some of them to distances of 200 miles, with resulting improvement in speed and accuracy.

Trials are being conducted between Detroit and New York of an experimental new form of telephone conference service which permits a group of people in a room at one

place to talk with another group elsewhere as if they were all around one conference table.

Long Distance Facilities

The broad-band transmission systems, which have been developed in the last few years, provide for as many as twelve telephone conversations simultaneously over a single pair of wires. They have become particularly important, under present conditions, for supplying quickly and economically the additional toll circuits required. These systems also make it economical to use toll cable along many routes where open wire has heretofore been used. The reliability of toll service is thus increased. . . .



To meet the increased traffic, long distance facilities were extended in 1940 by about 500,000 circuit miles. Approximately one-third of these circuits were provided by means of broad-band transmission systems.

Portable radio telephone equipment was used upon several occasions during the year as an aid in restoring service temporarily by bridging gaps in wire lines caused by severe storms. The number of portable two-way radio telephone sets available at strategic points throughout the System is being increased considerably.

The advent of frequency-modulation (FM) broadcasting has stimulated interest on the part of broadcasters in wire circuits which will transmit a broader frequency band than the 5,000 cycle range carried by the wire networks now generally used in transmitting broadcast programs. For long distance transmission, channels 60 per cent wider can be provided by the Bell System Companies. For service between studios and transmitters some broadcasting stations are already being furnished channels which transmit frequencies up to 15,000 cycles. The Bell System developments in this field will continue to keep abreast of the needs of the broadcasting industry.

Radiotelephone

Substantial increases were experienced in overseas traffic with Central and South America and with Hawaii, the Philippines and The Netherlands Indies.

A local ultra-short wave radio system which was installed in New York City in 1940 furnishes connections between the wire telephone system and motor vehicles of public utilities in times of emergencies.

Telephone service by radio to coastal and harbor vessels continued to increase. New Bell System radio telephone stations for this service were opened during the year.

"The Telephone Hour"

After a series of local and regional experiments with radio broadcasting programs extending through several years, the Bell System started a nation-wide program in April, 1940. The program is heard regularly every Monday evening over one of the major radio networks.

Telephone Rates

During 1940, reductions in Bell System telephone rates resulted in savings to telephone users of some $13,500,000 annually, of which over $5,000,000 was due to the reduction in this Company's long distance rates, effective May 1, 1940. . . .

These rate reductions have, on the whole, been made possible by improved and more economical methods of operation, maintenance and manufacture, and above all by fundamental progress in the telephone art growing out of scientific research. This scien-

tific research, while it has brought about large economies in practically all telephone operations, has, from the very nature of the telephone art, produced especially striking economies in telephoning over the longer distances. Mostly as a result of this, more than one-third of the amount of the rate reductions during the past ten years has been in interstate rates, although less than 2 per cent of Bell System messages and only about 15 per cent of Bell System gross revenues are interstate.

Research

In the Bell Telephone Laboratories there are about 4,600 people, of whom some 2,000 are scientists and engineers. Another thousand are draftsmen, laboratory assistants, skilled mechanics and technicians. The remainder are staff and service employees. The value of maintaining this research and development organization and the extensive laboratories in which they work is strikingly emphasized by present emergency conditions.

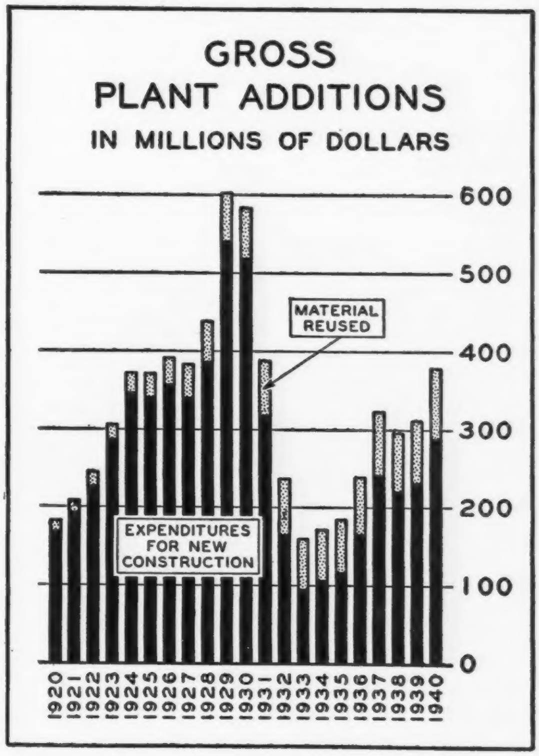
The technical problems involved in giving special telephone service to the military establishment, and the requests of the Army and Navy for new types of communication equipment, are being met satisfactorily by the Bell Telephone Laboratories.

In June, 1940, the experimental coaxial cable between New York and Philadelphia was used successfully for television transmission of the National Republican Convention in Philadelphia to New York City, where it was broadcast by the National Broadcasting Company over its television transmitter. The total length of circuit was 102 miles, including local connections of some three miles at each end in ordinary telephone cable. The use of wires in ordinary cables for local television circuits may be of considerable importance in the future, and the Laboratories have developed, on an experimental basis, associated equipment to make such transmission possible.

Wires, their covering and supports are elements of fundamental importance in furnishing telephone service and are subject to continuous development. Recent typical improvements are: the use of cellulose acetate in place of silk for the insulation of wires and cables in central offices; synthetic rubber covering for wire used in telephone installations to give better appearance and durability; drop wire of longer life for connection between pole lines and subscribers' premises; and a method of fastening aerial cables to the supporting strand by a spiral lashing of steel wire.

Rubber-covered wire plowed into the ground along highways or private rights of way is being used for reaching subscribers in some rural districts. For other rural situations, economical open-wire lines have been devised that use long spans of high-strength steel wire, thereby reducing the number of telephone poles needed.

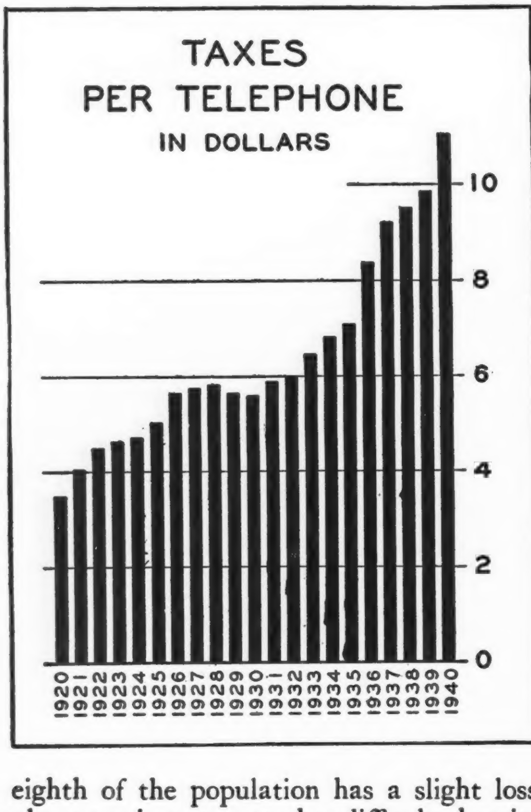
Many extensive wire networks are used to give private teletypewriter service to large business concerns. An automatic switching



arrangement has been recently developed for such service to provide rapid and accurate routing of any message to its destination by code letters typed at the head of the message by the sending operator. A system of this type, with a network extending to many of the important cities of the United States, was established for a large manufacturing company in 1940.

A valuable survey of hearing sensitivity has been obtained from the three million

hearing tests made in the Bell System exhibits at the New York and San Francisco Fairs. These tests give definite data on loss of hearing; for example, the loss for the higher pitch sounds is as great for men at 45 as for women at 55 years of age. Also, one-eighth of the population has a slight loss; about one in 25 persons has difficulty hearing in auditoriums, one in 125 in direct conversations, and one in 400 in using the telephone without the aid of the amplifying equipment which is available for the hard of hearing. Such information is being used in the design of telephone equipment and hearing aids.



A method of recording and reproducing music "stereophonically," which has been developed by the Laboratories, was demonstrated in 1940. This method enables the listener to hear every sound he could have heard during the original playing of the music, and also gives him the same sense of the direction from which each sound comes that is experienced when listening to an orchestra on a stage. In addition, through a re-recording process, the artist or director whose playing is recorded can vary the volume and change the tonal color of the music to suit his taste, softening it or amplifying it to a volume as great as ten times that of any orchestra.

A new handset coin-box telephone has been standardized after field trials. A new material, vicalloy, has been developed with mechanical and magnetic properties particularly suitable for magnetic tape recording like that used in the announcement of weather reports over the telephone.

Manufacture

The System's need for additional plant facilities to provide for the increased rate of telephone growth, together with Government requirements for communication equipment for the military defense services, resulted in greatly increased activity for the Western Electric Company.

Benefit and Pension Plan

The Plan for Employees' Pensions, Disability Benefits and Death Benefits has operated successfully as a valuable aid to the business since its adoption, twenty-eight years ago.

In the light of actuarial studies completed during the year, revised service pension accrual rates were made effective in the Bell System Companies, including the Western Electric Company and the Bell Telephone Laboratories, as of January 1, 1940. These increased accrual rates were made necessary by the effect of the adjustment of service pensions resulting from the 1939 amendments to the Social Security Act, by proportionately fewer employee separations from the service prior to retirement, and by lower interest earnings on Pension Fund investments. The pension accruals which were charged to expenses and added to the Pension Trust Funds amounted to $26,734,000, during 1940, or 4.4 per cent of the payroll.

The balance in the Pension Trust Funds maintained by the Bell System Companies, including the Western Electric Company and the Bell Telephone Laboratories, aggregated $296,191,000 at the end of 1940. Service pension payments made during the year from these Trust Funds were $8,496,000. At the end of the year there were 9,897 retired employees on the service pension rolls, of whom 6,879 were men and 3,018 were women.

Savings and Insurance Plans

Participation by employees in payroll allotment plans maintained by the Companies to assist them in accumulating savings in the form of life insurance, deposits in savings institutions and United States Savings Bonds continued to increase during 1940. These plans are designed to make it easy and convenient for employees to save part of their earnings for future needs. All administrative expenses are borne by the Companies. Employees are completely free to use the plans or not, as well as to decide as to the amount and purpose of whatever allotments they wish to make.

At the end of 1940, under the life insurance plans, 83,150 employees of the Bell System, including the Western Electric Company and the Bell Telephone Laboratories, were carrying regular life insurance totalling $259,350,000. Total premiums paid through these plans during 1940 amounted to $8,400,000. . . .

The plans for purchasing United States Savings Bonds were being used by 21,350 employees at the end of 1940. Payroll allotments for the purchase of these bonds amounted to $2,935,000 during the year.

Employees using the plans for deposits in savings banks and institutions of their selection numbered 115,000 at the end of 1940.

A National Asset

As 1940 ended, it found the Bell System meeting fully the increased demands upon it, including those growing out of the national defense program. In these critical times, national defense is the concern of all. Communications are an essential part of national defense and it is encouraging to know that telephone facilities in this country are by far the most comprehensive and the best in the world.

Telephone service in the United States is the result of initiative and ability, fostered and given free rein in an enterprise privately owned and privately managed. The Bell System is financially sound. It contributes to the support of Government one-half million dollars a day in direct taxes. It has the best telephone equipment in the world. This equipment has been provided out of the voluntary savings of hundreds of thousands of men and women. The System has a great scientific laboratory, which is constantly improving the communication art in which it has always been the leader. The Western Electric Company, manufacturer of telephone equipment for over sixty years, is the System's service of supply, with stocks of apparatus and materials in warehouses strategically located throughout the nation. With 21,000 motor vehicles in its construction and maintenance services, the Bell System has a highly mechanized and mobile fleet, which, along with standardization of materials and of methods of work throughout the country, makes possible the rapid concentration of men and materials wherever needed with a maximum of efficiency. Above all, trained and experienced men and women and the management are accustomed to work together and to plan ahead so that the right material and the right skill will be at the right place at the right time. By training they are competent and by tradition they are pledged to keep the lines of communications open and to see to it that the message gets through at all times and under all circumstances. The American Telephone and Telegraph Company and its Associated Companies in the Bell System can be counted on to continue to do their part in protecting and promoting the welfare of the nation.

WALTER S. GIFFORD,

March 4, 1941. *President.*

News of the Month

Television Demonstration for F.C.C. and N.T.S.C.

A demonstration was held for the Federal Communications Commission and the National Television Standards Committee in which television transmission over the coaxial loop from New York to Philadelphia and return was compared with local transmission. To casual observation there was no appreciable difference between the two. Some of the distortions which may appear in a television picture after transmission over a very long wire circuit were described and illustrated. O. E. Buckley officially welcomed the visitors and described for them various pieces of apparatus and cable used in the coaxial system. The demonstration was set up by L. W. Morrison, A. R. Kolding operated the control desk with J. J. Jansen at the monitoring equipment. L. S. O'Roark and G. F. Fowler attended to the arrangements for reception of the guests.

The Telephone Business

Construction of the last link in the first all-cable transcontinental telephone line to be built has been started along a 1,600-mile line from Omaha to Sacramento. In a move designed to assure additional coast-to-coast communication facilities to meet future defense needs, the Bell System will spend nearly $20,000,000 on the new underground link. The line is being placed underground along a carefully selected right-of-way that avoids highways and assures protection to the cables.

Supplementing several existing open-wire transcontinental lines, the new extension will increase transcontinental circuits initially by about 50 per cent and is expected ultimately almost to triple present facilities.

The line will consist of two cables buried for almost their entire length by a special tractor-hauled "plow train." Construction gangs now moving westward from Omaha and Grand Island, Nebraska, are expected to reach Laramie, Wyoming, by the end of the year. Other gangs will start eastward from Sacramento along a route that touches Denver and passes through Cheyenne and Salt Lake City.

Colloquium

W. O. Baker discussed *The Molecular Origin of the Properties of Some Synthetic Plastics* at the January 13 meeting of the Colloquium. The basic reasons for the useful properties shown by animal and vegetable fibers have long been the objects of investigation. Although notable technical progress in the use of these materials has been achieved, there is still little knowledge of the physico-chemical causes of their utility. Two chief postulates of the constitution of natural polymeric substances, like cotton (cellulose) and silk (fibroin), have been proposed. The first attributes the physical properties to minute, discrete crystallites or "miscelles," whereas the second emphasizes the importance of long, string-like molecules consisting of chains of atoms. Recent work on synthetic fiber-forming compounds has confirmed the second concept, and also agrees with the crystalline characteristics previously observed. Synthetic protein-like polymers known as polyamides are especially good subjects for investigation of internal structure, since they readily form fibers and exhibit other plastic behavior. This, and certain mechanical properties such as flexibility, elasticity and hardness, can be qualitatively explained in terms of molecular constitution. A striking analogy of these organic materials to the behavior of metals on heat treatment has been found.

At the January 27 meeting, Professor John J. Trump of Massachusetts Institute of Technology spoke on *Pressure Insulated Van de Graaff Generators*. Techniques de-

veloped by Professor Trump have recently made possible the production of over one million volts of direct-current potential in a compressed air tank less than five feet high and three feet in diameter. He described the operating principles and development of compressed-gas-insulated Van de Graaff generators and associated acceleration tubes, with emphasis on the latest insulation and design technique. Two X-ray sources now under development at M.I.T., one rated at 1.25 and the other at 3.0 megavolts, were discussed, together with experiments pointing toward increased compactness and more general application of this type of high-energy radiation source.

E. L. Norton discussed *A Point-by-Point Method of Measuring Flux, Current and Motion During the Operation of an Electromagnet* at the February 10 meeting. Mr. Norton described a machine which has been designed to measure the flux and current as a function of time during the operation of a relay or other magnetic structure. Flux may be measured either in a search coil or in the main windings of the relay. The time during the cycle at which flux and current are to be measured may be set within a small fraction of a millisecond by a worm-drive dial, and the instantaneous flux or current read directly on a direct-current microammeter in the output. Five accurately held pulse rates are available by the use of gear trains driven by a synchronous motor. Additional equipment involving the use of a photoelectric cell makes possible the measurement of displacement or velocity of the armature. For measurements of displacement the amplifier has uniform gain down to direct current, and for velocity measurements it has a voltage gain proportional to frequency up to several thousand cycles. By holding all important electrical and mechanical parts to close limits, it is believed that an accuracy has been attained superior to any method of similar measurement which has previously been used.

News Notes

At a meeting held in commemoration of the life and work of Alexander Dallas Bache together with a symposium on geomagnetism, F. B. Jewett presented an address on Bache as *Founder, First President and Benefactor of The National Academy of Sciences*. The meeting was held in Philadelphia on February 14 and 15 with the coöperation of The American Philosophical Society, United States Coast and Geodetic Survey, Department of Terrestrial Magnetism, Carnegie Institution of Washington and Girard College.

The paper *Engineering Progress and the Social Order*, by F. B. Jewett and R. W. King, presented before the Section on Natural Sciences of the University of Pennsylvania Bicentennial Conference, was published in the December 28 issue of *Nature*.

Members of the Laboratories who have been granted leaves of absence to enter military service are D. F. Ciccolella and R. A. Devereux, 207th Coast Artillery, Camp Stewart, Hinesville, Georgia; R. D. Horne, Headquarters Troop, 101st Cavalry, Fort Devens, Massachusetts; H. T. King, Field Artillery Replacement Center, Fort Bragg, North Carolina; H. N. Misenheimer, Headquarters, Air Defense Command, Mitchel Field, New York; F. A. Parsons, Ordnance

G. A. Campbell receives the Edison Medal from R. W. Sorensen, President of the A.I.E.E., during the winter convention of the Institute in Philadelphia

W. M. Beaumont
of the Switching Development Department completed thirty years of service in the Bell System on February 6

R. P. Maclaren
of the Equipment Development Department completed thirty-five years of service in the Bell System on February 9

L. J. Bowne
of the Switching Development Department completed thirty-five years of service in the Bell System on February 19

Training Center, Camp Rodman, Aberdeen Proving Ground, Aberdeen, Maryland; M. A. Specht, Battery C, 186th Field Artillery, Madison Barracks, Sacketts Harbor, New York; and J. H. Stelljes, Company B, 51st Signal Battalion, Fort Monmouth, New Jersey. A. W. Clement, with the Coast Artillery Officers Reserve Corps at Fort Monroe, Virginia, was recently appointed a member of the Coast Artillery Board.

H. V. Wadlow visited the Warner Chemical Company plant at Carteret, New Jersey, to discuss with their engineers trichlorethylene degreasing problems.

F. F. Lucas spoke on *Late Developments in Microscopy* before the Basic Science Group of the New York section of the A.I.E.E.

Studies on panel-bank contact performance were made in Buffalo by B. L. Clarke, H. W. Hermance and R. L. Slobod.

J. A. Becker spoke on *Varistors and Some of Their Uses* before the Washington section of the A.I.E.E. on January 14.

R. M. Burns visited Princeton University and the University of Pennsylvania to interview prospective employees.

Mr. Burns gave a talk before the Design Forum of the Laboratories on *Corrosion of Telephone Apparatus*, also the New York Telephone Company on *Chemical Problems in the Telephone Plant* and the Mathematical Physical Chemical Club of Westfield, New Jersey, on *Corrosion of Metals and Its Prevention*.

H. G. Arlt and C. C. Hipkins were at Kearny in connection with coating varistors.

J. D. Cummings and J. M. Finch, at the Point Breeze plant, discussed cable paper problems.

K. K. Darrow and W. J. Shackelton are members of a committee formed by the National Research Council to publish a table of fundamental physical constants. The work will cover atomic and thermodynamic constants, nuclear masses and isotopic ratios, and miscellaneous constants such as ratios of the International and absolute electrical units and Faraday and electrochemical equivalent of silver.

An article entitled *Debt of Modern Physics to Recent Instruments* by K. K. Darrow was published in the January issue of *The Review of Scientific Instruments*.

Dr. Darrow spoke on *Artificial Radioactive Substances* before the North Jersey section of the American Chemical Society at a meeting held in Newark on January 13.

F. S. Goucher, assisted by J. R. Haynes, presented his lecture-demonstration, *The*

Microphone and Research, before the Mansfield A.I.E.E. section on January 7, a joint meeting of the four Cincinnati scientific societies on January 9, the Western Society of Engineers in Chicago on January 14, and the Hawthorne Science Club on January 15.

W. A. SHEWHART presented his paper, *Some Comments on the Contribution of Statistics to Scientific Method*, before the Statistics Discussion Group of the American Statistical Association at Columbia University, January 10.

AT A MEETING of the Radio Colloquium, held at the Deal radio laboratory on February 7, E. B. FERRELL discussed *Some Special Problems in Relay Research.*

AT THE UNIVERSITY of Illinois on February 11, HOMER DUDLEY presented his lecture-demonstration, *The Vocoder*, before the senior and student sections of the A.I.E.E. He was assisted by C. W. VADERSEN. This demonstration was also given on February 13 in the Auditorium of Marquette University Medical School before the Milwaukee Section of the A.I.E.E., and on February 18 at Columbus, Ohio, before the Annual Broadcast Engineering Conference.

AT THE HAWTHORNE PLANT of the Western Electric Company, J. R. BARDSLEY discussed loading coil cases for the Omaha-Denver cable project; K. G. COUTLEE, insulating materials and the manufacture of porcelain parts; D. H. GLEASON, crossbar switches; C. C. BARBER, special central-office panel equipment; and M. D. RIGTERINK, the manufacture of ceramics.

W. FONDILLER and V. E. LEGG visited the factory of the H. W. Crowley Company at West Orange, New Jersey, on January 16 on matters pertaining to cores for radio-frequency coils.

ON SEVERAL OCCASIONS during January, C. A. WEBBER and R. T. STAPLES were in Point Breeze on matters pertaining to cord development problems.

W. A. BISCHOFF, with W. C. MUELLER of the Western Electric Company at Hawthorne, visited the Ford Motor Company at Dearborn to examine various features of the decimal dimensioning system used by the Ford Company. Mr. Bischoff then visited Hawthorne in connection with problems of dimensioning drawings.

AT THE KEARNY PLANT of the Western Electric Company, A. J. CHRISTOPHER and T. B. JONES discussed the development of silvered mica condensers; V. E. LEGG and J. E. RANGES, the manufacture of the 274-type retardation coil; and R. W. DEMONTE, finishes on transformers.

W. E. INGERSON spent some time at the Chester laboratory setting up a "dancing" wire test.

H. O. SIEGMUND visited the South Norwalk central office of The Southern New England Telephone Company in connection with the installation of step-by-step switching apparatus.

J. R. TOWNSEND discussed *High-Speed Moving Pictures* before a meeting of the Morris County Engineers' Club held in Morristown, New Jersey, on January 20. Mr. Townsend has been appointed Chairman of a sub-group of Committee B-32 of the American Standards Association to study the standardization of wire sizes.

W. S. BOERCKEL
of the Transmission Apparatus Development Department completed thirty-five years of service on February 5

JAMES BARTON
of the Plant Department completed thirty years of service in the Bell System on the fifteenth of February

W. J. Leveridge

A. W. Kishpaugh

F. H. Hibbard

R. W. Bogumil visited the intertoll dialing installations at Columbus, Springfield, and Dayton, Ohio, to investigate the use of silver inlays for step-by-step banks.

F. Hardy visited the Court Street central office of The Southern New England Telephone Company in New Haven to study the lubrication of step-by-step switches.

H. L. Coyne and D. W. Pitkin examined the lubrication on the timers at the Troy Avenue central office in Brooklyn.

C. H. Wheeler and N. J. Eich were at the Bayonne central office of the New Jersey Bell Telephone Company to investigate the operation of line relays.

The use of ultra-high-speed motion pictures in time and motion study was discussed and illustrated by W. W. Werring and H. B. Smith before a joint meeting of the American Society of Mechanical Engineers and the Society for the Advancement of Management. The meeting was held in New York City on January 16.

* * * * *

W. J. Leveridge completed twenty-five years of service in the Bell System on the ninth of February. Mr. Leveridge attended Northampton Institute in London for three years and then, in 1913, came to the United States where for three years he worked with the Wilson Maeulen Company, manufacturers of pyrometers and pyrometric apparatus. He joined the apparatus design group of the Western Electric Engineering Department in 1916 but soon transferred to the research design group where he was engaged in the development of telephone transmitters, filament coating apparatus and other vacuum-tube manufacturing devices. During the war period he was associated with the design of binaural submarine and airplane detection apparatus.

In 1921 Mr. Leveridge transferred to the Commercial Products Development Department where for the next seven years he was associated with the design and construction of large wooden horns for sound pictures. These included 11- and 14-foot horns and an experimental 38-foot horn that was installed in Grand Central Palace for demonstration purposes. During this time he also worked on hard-of-hearing sets, the 6A transmission measuring set, sound picture equipment and the commercial design of an oscillograph, twelve of which were used for automatically recording transients caused in telephone lines by a railroad electrification.

Mr. Leveridge joined Electrical Research Products, Inc., in 1928 where, in the recording engineering group, he was concerned with problems encountered in disc and film recording. Much of his time was spent in field work with the companies using Western Electric recording equipment. In 1937 he returned to the Research Staff Department of the Laboratories and for the next two years he was interested in a project in which about fifty per cent of the storage

batteries used in the various Laboratories at West Street and in the Graybar-Varick building were replaced with rectifiers. Since 1939 Mr. Leveridge has been in the Circuit Research Department engaged in the design and development of experimental telephone apparatus, particularly relays and multi-unit switches.

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After A. W. KISHPAUGH graduated from the University of North Dakota in 1912 with an E.E. degree, he spent two years with the General Electric Company, first on the test course and then in the consulting and transformer engineering groups. He then joined the Utah Power and Light Company on operating and maintenance work, particularly in hydroelectric plants. Mr. Kishpaugh joined the Engineering Department of the Western Electric Company in 1916 and thus began his service in the Bell System which reached the twenty-five-year mark on the twenty-eighth of February. His first work was in the research group where he was concerned with radio receiving problems and with the development of radio equipment for the Army and Navy, particularly the use of this equipment on aircraft.

Following this Mr. Kishpaugh was engaged in the development of apparatus and systems for the commercial applications of radio telephony and in the development of broadcasting equipment. He was intimately associated with the development of broadcasting transmitters from the early days of the 100 and 500-watt units and made many contributions in this field during the next fifteen years. Under his supervision a group was formed to develop the use of quartz crystals for radio-frequency control. The first application was to radio broadcasting transmitters and later these crystals were applied for the accurate maintenance of frequency in other radio equipment. He was also associated with police-radio systems.

Mr. Kishpaugh transferred to the Patent Department early in 1939 and since then has been concerned with the preparation and prosecution of patents covering radio systems, particularly in the high-frequency field.

* * * * *

F. H. HIBBARD of the Switching Apparatus Development Department completed twenty-five years of service in the Bell System on February 19. Mr. Hibbard received the M.E. degree from Cornell University in 1914 and immediately joined the Engineering Department of the Western Electric Company. After a year in the student course in Hawthorne and New York, he joined the Transmission Department where he engaged in transmission calculations, patent examination and loud-speaker testing. He left the company in 1916 and when he returned in 1918 entered the machine-switching laboratory, of which he was placed in charge in 1921; he remained in this position during the next six years while the panel system was being incorporated in the Bell System. In 1927 he was assigned to special instrument studies and to budget and laboratory cost studies. Later he was placed in charge of a group developing various types of relays for the panel system.

F. S. Goucher inspects a piece of anthracite coal, from which carbon is made, on his trip through the Hawthorne works of the Western Electric Company. H. E. Mali is in the center and Walter Finnell on the left.

In 1929 Mr. Hibbard transferred to Electrical Research Products, Inc., where he was soon placed in charge of the engineering group responsible for sound recording on disc and film. In this connection he was instrumental in isolating and measuring sound distortion known as "flutter" and aided in apparatus development to keep this effect

B. C. Bellows of the Laboratories with J. V. Bell and T. H. Johnson of the Michigan Bell Telephone Company at the cutover of the new dial system at Bay City, Michigan

within commercial limits. He returned to the Laboratories in 1935 to take charge of a group in special products development, particularly sound picture recording work and the commercialization of magnetic-tape recording apparatus. Since 1937 Mr. Hibbard has been in the Switching Apparatus Development Department where he has been responsible for improvements in the design and development of selector switches for step-by-step systems among the more important of which has been the design of the new 210A selector and the redesign of the 197-type switch.

* * * * *

A FIVE-STAR EMBLEM signifying the completion of twenty-five years of service was awarded to W. E. HARNACK on the twenty-first of February. Mr. Harnack joined the Model Shop of the Western Electric Engineering Department in 1916 as an instrument maker. Early in 1918 he left to join the 33rd Division of the 108th Engineers and was in action in France at both the Argonne Forest and St. Mihiel. After the Armistice he went to Luxembourg with the Army of Occupation.

Returning to the United States in June, 1919, Mr. Harnack immediately came back to the Model Shop at West Street. A short time after this he was sent to Worcester for a period of six months to inspect vacuum cleaners being manufactured for the Western Electric Company. A year after his return he became a supervisor in the shop and since then has been concerned with printing telegraph equipment, high-speed relays, sound picture apparatus, microphones, loud speakers, rapid-record oscillographs and various other telephone apparatus. For the past year and a half he has been a supervisor in Section 4B responsible for sheet-metal work, arc and spot welding, engraving, assembly of filter networks for the coaxial systems, and for the shop work required for the vacuum tube group in Building R.

* * * * *

H. F. BECK, who completed a quarter century of service with the Western Electric Company and the Laboratories on February 28, first worked in the Physical Laboratory testing switchboard lamps and condensers. In September, 1917, he left to enter military service. The first three months of this service was with the 302nd Engineers at Camp Upton; he then went to Washington with the Bureau of Aircraft Production and for the next year, at the National Bureau of Standards, designed airplane apparatus, particularly oxygen supply equipment and bomb sights.

Early in 1919, Mr. Beck returned to the Western Electric Company as a draftsman in the Apparatus Design Department. Later that year he transferred to the equipment engineering group at Hawthorne where he was engaged in layout work in connection with panel office equipment. Returning to West Street in 1921 he continued this same type of work until 1927 when he went to the Patent Department. Since then Mr. Beck has been preparing and supervising the execution of patent drawings. In line with this work he has also been called upon in certain court proceedings to aid in the preparation of drawings and sketches during the presentation of testimony.

On the twenty-fourth of February K. G. Coutlee of the Switching Apparatus Development Department completed twenty-five years of service with the Western Electric Company and the Laboratories. Since his early years with the Engineering Department of the Western Electric Company he has been concerned primarily with the electrical characteristics of all types of insulating materials, particularly their dielectric losses under low-potential telephone frequencies and low and high-potential radio frequencies. In the early twenties he was instrumental in designing and developing special laboratory testing equipment used in apparatus and insulating materials studies at radio frequencies.

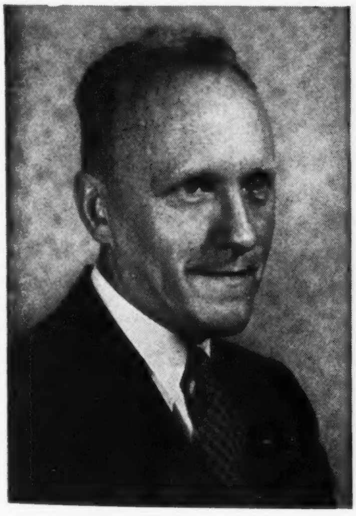
Most of the time since 1928 Mr. Coutlee has been associated with what is now the materials standards group of the Switching Apparatus Development Department where he has dealt with insulating material problems and the development of testing methods and specifications for raw materials such as waxes, compounds, sheet and molded insulating materials and ceramics used in telephone apparatus.

For the past several years he also has been active in the work of Committee D9 of the A.S.T.M. covering electrical insulating materials.

W. E. Harnack

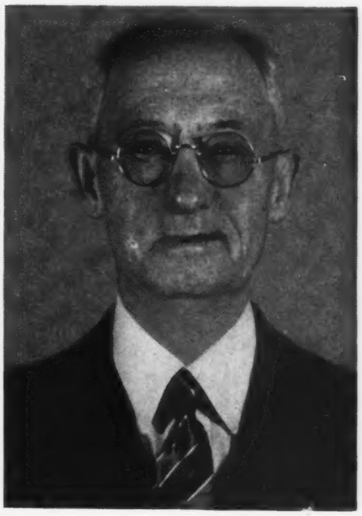
* * * * *

Prior to his coming with the Engineering Department of the Western Electric Company in 1917, G. C. Cummings had wide experience, dating back to 1892, with various railroad systems, the Western Union, and as a wire chief of the Morrell Park Office of the A. T. & T. in Chicago. While employed with the Burlington Railroad as General Circuit Manager he developed telephone-train dispatching and telephone message circuits to the point where as many as thirty-six stations could be connected across the line at one time without serious impairment of telephone transmission. This was accomplished by a tapered distribution system for the voice currents and the use of a booster telephone set developed by him which enabled the talker to put out much greater power without excessive sidetones. Another feature of these systems was the ability to select and ring any individual station or a group of stations from the control office. For this purpose Mr. Cummings developed a selective system which was used on many of the important railway systems of the country.



H. F. Beck

K. G. Coutlee



G. C. Cummings

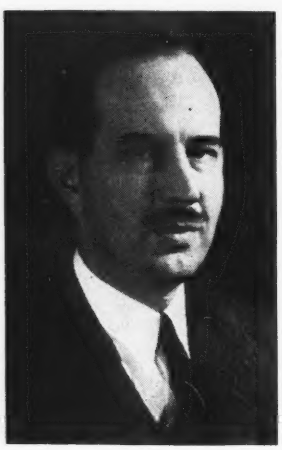
Instructors for 1940-1941 Out-of-Hour Course "Application of Vacuum Tubes"

T. Slonczewski

L. A. Meacham

C. R. Burrows

D. E. Trucksess



W. T. Wintringham

J. O. Edson

M. A. Logan

E. K. Van Tassel

B. D. Holbrook

R. P. Jutson

J. M. West

Since coming with the Laboratories, Mr. Cummings has been a member of the Telegraph Systems Department and has been responsible for the development of numerous telegraph transmission systems among which might be mentioned the type-B polarential system. This system automatically compensates for the effect of leakage on open-wire lines. A few of the other systems with the design of which he has been actively concerned are metallic telegraph, T.W.X., 101 and 102 concentrators, telegraph conference systems, 16B1 open-wire system, 110-type multiple senders, 118-type telegraph transmission measuring sets, and the No. 1 telegraph service board. Among the more than forty patents which have been issued to Mr. Cummings may be found the one that covers the design of the anti-chatter contacts that are employed on 209, 215, 255 and 239 type relays.

Mr. Cummings' service with the Bell System, including that with the American Telephone and Telegraph Company in 1904 and 1905, reached the twenty-five-year mark on the fourth of February.

* * * * *

R. V. Terry visited the Calculagraph Company in Harrison, New Jersey, to discuss the design of calculagraphs.

R. H. Colley, at the annual meeting of the American Wood Preservers' Association held in Louisville during the week of February 3, was elected second vice-president for the coming year.

Dr. Colley delivered a talk on the selection, manufacture and preservation of wood poles before the Albany Society of Engineers on January 28.

M. C. Biskeborn came to New York from Point Breeze for a discussion of impedance bridge measurements at high frequencies and J. W. Kennard came to discuss toll-cable development problems.

J. H. Gray, S. M. Sutton and E. S. Wilcox have been in St. Louis carrying on studies on the changes taking place in performance characteristic of toll cable caused by its installation.

E. S. Wilcox was in St. Charles, Missouri, for measurements to determine to what extent electrical characteristics of toll cables are changed due to placing the cables in underground ducts.

R. G. Koontz, E. G. Andrews and C. V. Taplin, together with A. T. & T. and Western Electric Installation Department engineers, discussed additions to crossbar central offices in Washington.

J. Nedelka was in Philadelphia and Princeton in connection with the installation of type-L coaxial equipment.

During the month of February the following members of the Laboratories completed twenty years of service in the Bell System:

Research Department

L. B. Cooke — J. R. Fisher

Miss Mary K. Corr

Apparatus Development Department

W. E. Kahl

Systems Development Department

Walter Kuhn — O. L. Michal

G. F. Sohnle

General Service Department

Harold Kuhn — Herbert Maude

Patent Department

I. A. McCorkendale

Plant Department

W. J. Hahn

D. C. Meyer, E. F. Watson and J. Shea were in Cleveland to discuss proposed teletypewriter private-line facilities with representatives of the Long Lines and Western Electric Company.

B. H. Carmer, with engineers of the Western Electric Company, inspected a new installation of a 3C toll switchboard at South Norwich, Connecticut.

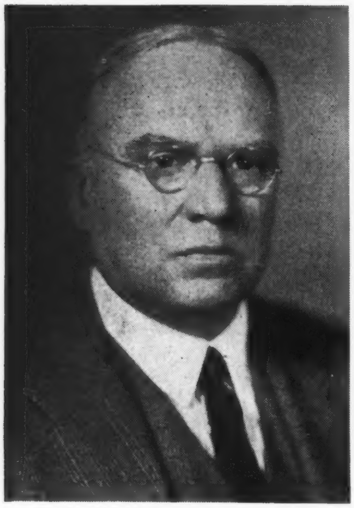
A new installation of program-switching equipment at Cleveland was visited by J. P. Hoffmann, together with Long Lines and Western Electric engineers.

H. Keppicus was in Philadelphia and L. R. Schreiner in Princeton to arrange for the trial installation of terminal equipment for the coaxial cable between New York and Philadelphia.

A. E. Petrie and V. T. Callahan attended engine conferences at Detroit and Canton. Mr. Petrie was also in Philadelphia for the A.I.E.E. convention.

J. H. Sole, at Cleveland, discussed the design and manufacture of diverter-pole generators.

R. G. Watling, at the New York Telephone Company, Albany, discussed maintenance of certain switching apparatus.



H. F. DOBBIN, 1871-1941

ALFRED WOLFF, 1876-1941

H. T. LANGABEER, on a recent trip to Chicago, discussed power plants with engineers of the Illinois Bell Telephone Company and the Western Electric Company.

F. T. FORSTER, at Philadelphia, discussed the manufacture of batteries.

G. A. HURST spent most of January in Detroit on matters connected with installation and testing of the Atlantic, Lincoln Park and Michigan crossbar offices of the Michigan Bell Telephone Company.

E. W. HANCOCK was in Chicago for several days where he discussed the testing of the South Chicago crossbar office of the Illinois Bell Telephone Company. He also spent several days at Baltimore on the Downtown crossbar office of The Chesapeake and Potomac Telephone Company.

A. F. BURNS and J. M. DUGUID visited Felton and Frederica, Delaware, to observe the operation of a new static tone generator in community dial offices. They were particularly interested in checking the tone quality being delivered by the generators.

M. E. KROM and R. L. KAYLOR, with T. I. ROGERS of the A. T. & T., were in Elmer, New Jersey, where they studied radio induction problems.

AT THE WINTER CONVENTION of the American Institute of Electrical Engineers, held in Philadelphia from January 27 to 31, R. G. MCCURDY presented a paper entitled *Engineering Requirements for Program-Transmission Circuits*, of which he was co-author with F. A. COWAN and I. E. LATTIMER of the A. T. & T. During his presentation of the paper, Mr. McCurdy demonstrated the transmission of orchestral music over channels transmitting band widths of 5000, 8000 and 15,000 cycles. To provide music, a pick-up was established in the Academy of Music, and coöperation of the Philadelphia Orchestra was enlisted to make available its music during a rehearsal.

To show how well long circuits can transmit wide frequency bands, a modified type-K carrier system was also inserted.

A. B. BAILEY, J. E. CORBIN, J. C. LOZIER, W. A. MACMASTER, C. C. TAYLOR and F. H. WILLIS participated in tests on the ultra-high-frequency radio telephone system to be used from Crisfield, Maryland, to Smith and Tangier Islands in the Chesapeake Bay. H. H. SPENCER inspected the power supply equipment for this installation.

* * * * *

H. F. DOBBIN, who retired in 1933 after twenty-six years of active service, died on January 28. Mr. Dobbin graduated from Alabama Polytechnic Institute in 1895 with a B.S. degree and for the next seven years worked for the Mergenthaler Linotype Company. He joined the Western Electric Company in 1903 and soon supervised a group which designed paper insulating machines for cables and a new machine for winding loading coils. He left in 1910 and returned three years later to the machine-switching drafting division and was subsequently placed in charge of this work. Later Mr. Dobbin was assigned to engineering duties and then became a supervisor on panel apparatus development which position he held until his retirement.

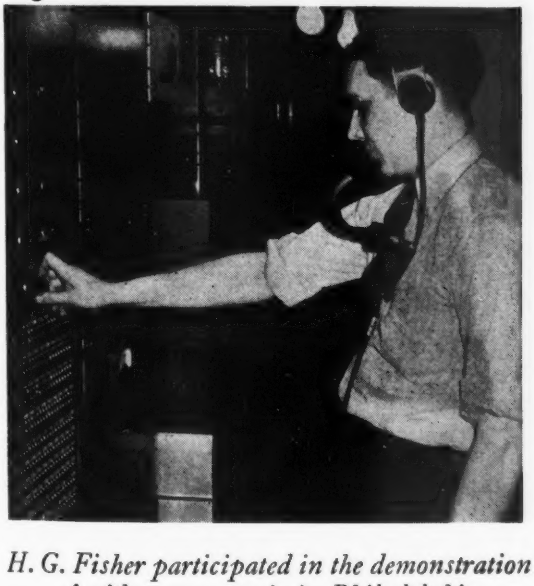
* * * * *

ALFRED WOLFF, who retired in 1932 after thirty-three years of active service, died on January 17. Previous to his retirement, Mr. Wolff had been in the Building Shop where he was a foreman of a group of millwrights.

This extended from Philadelphia to Charlotte and return via New York. Using another cable route of about the same length to Toledo and return, demonstrations were made with channel widths of 5000 and 8000 cycles. D. K. Gannett was in general charge of the demonstration. The installations at the Academy of Music and at the Town Hall, as well as the equalizing of local loops furnished by The Bell Telephone Company of Pennsylvania, were under the direction of Smart Brand and Iden Kerney. They were aided by S. Duma, H. G. Fisher and A. E. Ruppel. J. T. Schott assisted at the Academy during the demonstration. Special carrier equipment was in charge of R. S. Caruthers and R. D. Fracassi. Toll line facilities were furnished by the Long Lines Department.

During the convention, M. E. Strieby of the Long Lines Department and J. F. Wentz of the Laboratories presented a paper entitled *Television Transmission Over Wire Lines*. A communication network conference was attended by W. L. Casper, E. B. Payne, A. R. D'Heedene, A. G. Ganz, P. H. Richardson, D. T. Bell and G. H. Lovell. C. H. G. Gray also conducted a meeting of the Technical Committee of the American Standards Association that was devoted to Sound Levels and Sound Level Meters during the convention.

J. T. Schott was in Schenectady for a few days in connection with the field trial of the loud-speaking conference telephone system that has been installed there.



H. G. Fisher participated in the demonstration of wide-range music in Philadelphia

The first crossbar central office in the Michigan Bell Telephone Company's area, TOwnsend-9 in Detroit, was placed in service on December 2, 1940. In the photograph, left to right, are G. A. Hurst and O. H. Williford of the Laboratories and Luther Reynolds and Miles Welter of the Michigan Bell Telephone Company

H. C. Franke and L. L. Glezen visited Stevens Point and Minneapolis to make transmission tests on the coaxial system between these points.

E. A. Potter, accompanied by T. J. Maitland of the Long Lines Department, has been in Joplin, Missouri, to conduct lightning protection studies on buried cables between Kansas City and Joplin.

H. B. Noyes was in Washington and in Norfolk, Virginia, for crosstalk tests on cables over which type-K carrier systems are to be operated.

Equalization studies were made on the Stevens Point-Minneapolis coaxial by J. M. West, S. A. Levin and M. M. Jones. The system of grounding connections on coaxials at attended stations was inspected by H. H. Benning and modified grounding arrangements installed. G. R. Frantz and C. C. Fleming went to Minneapolis to obtain data for building phase equalizers for television over this circuit.

B. A. Fairweather and V. M. Meserve have returned from Stevens Point and Minneapolis, respectively, where they were engaged for several months in field tests of the terminals of the type-L carrier telephone

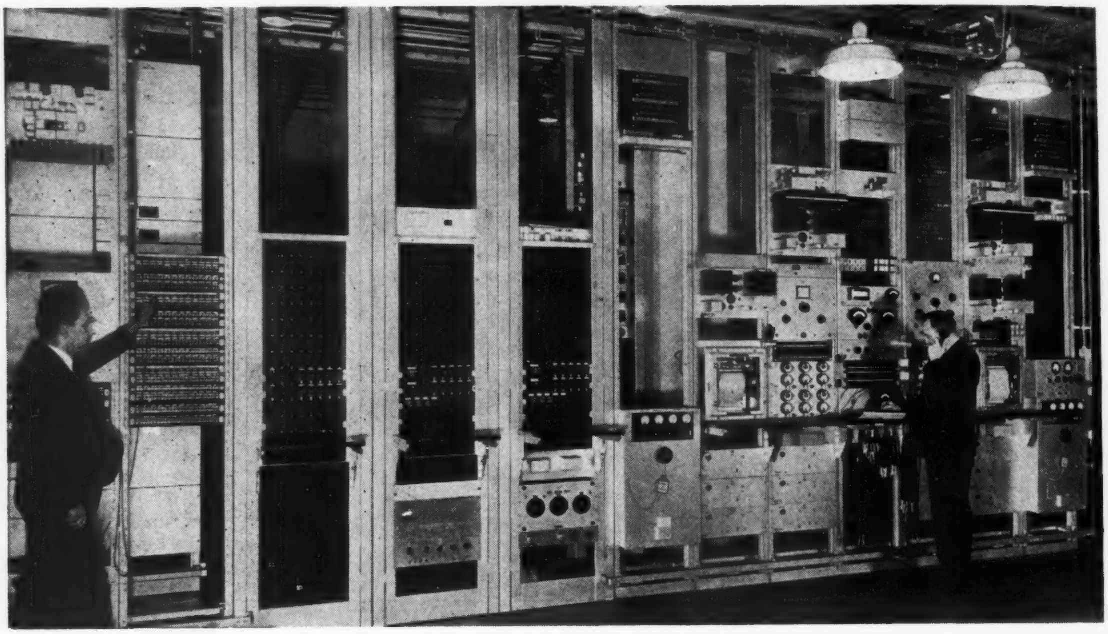
system between those cities. The field tests were concluded with a period of commercial service during which these engineers observed the performance of the equipment.

R. J. SHANK visited the RCA Manufacturing Company's plant in Camden to inspect new television pick-up equipment constructed for the Laboratories.

D. E. THOMAS and D. M. OSTERHOLZ have spent some time at Forked River on tests on buried-wire lines.

R. J. HEFFNER attended the 230th meeting of the National Industrial Conference Board which was held in New York City on January 23.

E. B. CAVE appeared before the Board of Appeals at the Patent Office in Washington relative to applications for patent.



Terminal repeater testing and patching equipment at Minneapolis for the Stevens Point-Minneapolis coaxial cable system. V. M. Meserve of the Laboratories is shown at the left and C. A. Flower of the A. T. & T. at the right

Polarential Telegraph Operation

By ALLAN WEAVER
Systems Development

GROUNDED telegraph circuits are sensitive to changes in the weather, since those changes bring about variations in line leakage and in line resistance. Where telegraph relays are located at subscribers' premises frequent readjustment is impractical; to avoid it, a new method of operation has been developed. It is called "polarential," and differs from "differential duplex" in that it operates in one direction on differences in current and in the other on reversals in current. It includes two types of circuits: one, type A, minimizes the effect of variations in line resistance, and is used on cable circuits; the other, type B, which is applied to open-wire lines, greatly minimizes the effect of variations in leakage.

In the type-A system the battery voltages at each end of the line are chosen so that the current in the line, although in opposite directions for marking and spacing conditions in either direction of transmission, has the same magnitude for both. A given change in line resistance will, therefore, affect both marking and spacing currents equally and cause no bias at the receiving relays. In the type-B system the voltage to ground at the middle of the line reverses but has the same magnitude for marking and spacing. A given leakage at the middle of the line will, therefore, cause a current to ground which is the same for marking and spacing and hence the change in the receiving relay current will be the same for these two conditions. These systems are used only on circuits that require the transmission of signals in one direction at a time, which is the type of transmission used on a large percentage of the circuits used in the Bell System.

The operation of the first system, designated type A, is explained more fully by Figure 1, which shows the sending and receiving relays of a west repeater connected over a line to the sending and receiving relays of an east repeater. When no transmission

is taking place the relay contacts are as shown in Figure 2. To transmit from west to east, the armature of the W sending relay moves between M and S (marking and spacing contacts). When it rests on M, current flows from the positive pole of the M battery through ground to the east end, through the M contact of the sending relay and the No. 1 winding of the E receiving relay (which it holds on M) thence over the line and through the No. 3 winding of the W receiving relay back to battery. An

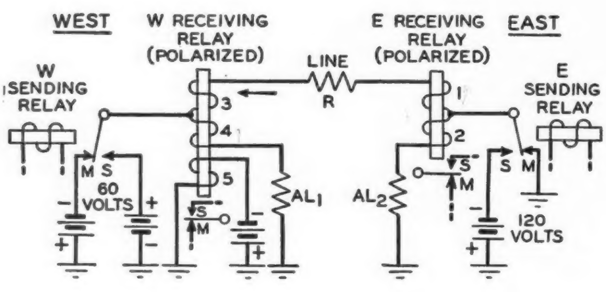


Fig. 1—Schematic of telegraph circuit for type-A polarential operation as used on cable lines

equal current is drawn through the artificial line AL_1 and winding 4 by the same battery but windings 3 and 4 are oppositely poled and their currents have no net effect on the relay. However, a local current in winding 5 holds the relay on M. If temperature variations change the line resistance the currents through windings 3 and 4 will no longer be equal but the unbalance is not enough under ordinary conditions to operate the relay falsely on outgoing signals.

When the W sending relay armature rests on S the line current flows in the opposite direction and the E receiving relay closes its S contact. Windings 3 and 4 are still in opposition and the W receiving relay remains on M. For transmission in the opposite direction (E to W), the M contact of the W sending relay remains closed. Current from a 60-volt battery flows steadily through winding 4, and the artificial line AL_1. The current through winding 5 is so adjusted that its magnetomotive force annuls that of winding 4. As the E sending relay operates its armature between M and S it alternately makes the net voltage on the line 60 volts E to W and $60-120=-60$ volts W to E. The resulting currents being equal and opposite will act through winding 3 to move its armature between M and S. Since they both flow through the line, any change in its resistance will affect them alike.

The line currents for the type-A operation normally have values shown by the *a* trace of Figure 2. When the cable becomes warm its resistance increases and the currents may have values shown by the *b* trace. The operating values for the receiving relay are shown by the upper and lower horizontal dotted lines respectively. Signals repeated by the receiving relay are shown by the *a*-1 trace and the *b*-1 trace. A comparison of trace *a*-1 with *b*-1 shows that the signals

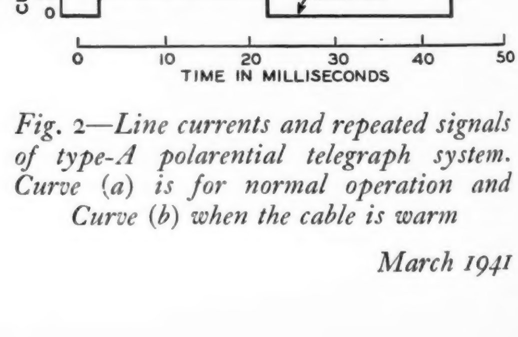


Fig. 2—Line currents and repeated signals of type-A polarential telegraph system. Curve (a) is for normal operation and Curve (b) when the cable is warm

are of equal length and thus are undistorted but that they have been displaced with respect to each other, which does no harm.

The other polarential system, designated type B, is shown schematically in Figure 3. Transmission from west to east is the same as in the type-A arrangement; when sending from east to west, ground is used for the marking condition as before but positive instead of negative 120-volt battery is applied to the line for the spacing condition. The net voltage around the whole circuit for the spacing condition in E-W transmission is therefore three times that for marking and in the same direction. The spacing current is also unchanged in direction but three times as great. When it flows in winding 3 of the west receiving relay it overpowers the current in windings 4 and 5, which oppose it, and pulls the armature to the spacing position. As in type-A polarential operation both receiving relays have balanced windings which are connected to the line and artificial line respectively, thus preventing false operation of the telegraph system on outgoing currents.

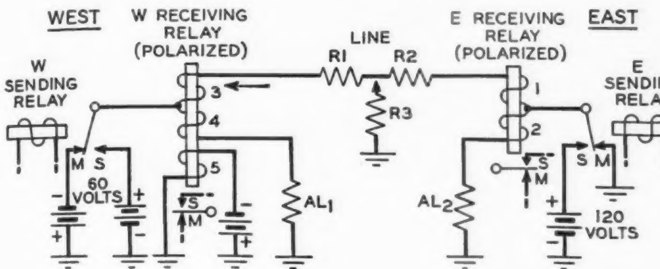


Fig. 3—Schematic of telegraph circuit for type-B polarential operation as used on open-wire lines

The effect of leakage on the type-B system can be shown by assuming that this occurs at the middle of the line and then considering the voltages in the circuit. With both senders in a marking condition and no leakage the voltage distribution along the line is shown by the lower solid line of Figure 4. When the east sender is operated to spacing the voltage distribution is that shown by the upper solid line. The marking voltage at the center of the line is equal to the spacing voltage but opposite in sign. If a leak is added at this point, the marking and spacing voltages will be reduced to new values, shown as $+e'$ and $-e'$, and these will also be equal to each other but op-

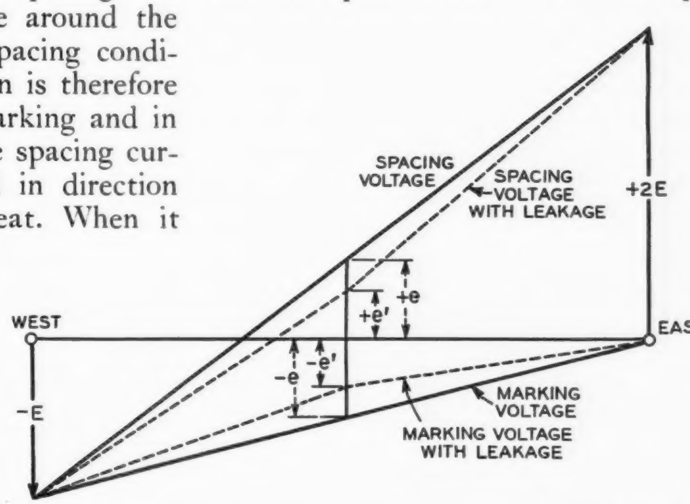


Fig. 4—The voltage distribution along the telegraph line for type-B polarential operation is shown by the upper and lower full lines of the figure when there is no leakage. With leakage the marking and spacing voltages will both be reduced as indicated by the dotted lines. In this description of polarential operation voltage drops through apparatus resistances have been ignored to simplify the diagram

posite in sign. When these voltage conditions prevail at the center of the line the signals received at the west end will be unbiased.

Referring again to Figures 3 and 4 the current received by the west relay is the algebraic sum of the voltage to ground at the center of the line e, and the terminal voltage, E, divided by the resistance of the line between the center and the west terminal, R_1, i.e. $\frac{E \pm e'}{R_1}$. The e' is minus for marking and plus for spacing and the biasing current will be set at the average of the two currents, or at E/R_1. The net effect on the relay will therefore be the difference between the biasing current and the line current, or $\frac{E}{R_1} - \frac{E \pm e'}{R_1} = \frac{\pm e'}{R_1}$. The net marking and spacing effects will therefore be equal to each other in magnitude but opposite in sign whatever the leakage. The actual magnitude of both the marking and spacing effects have, of course, been reduced by the leakage.

In the above considerations it has been assumed, for the sake of simplicity, that the leakage is lumped at one point in the middle of the line, while in a real line the leakage will be distributed along the line. For ordinary values of leakage this assumption gives results which closely agree with actual measurements, but when the leakage is very large a small amount of bias is introduced. Even in this case, however, the bias is very much smaller than it would be in previous grounded telegraph systems.

Type-A and type-B polarential methods of operation are now available in many Bell System open-wire and cable telegraph repeaters. These improved methods of controlling leakage and resistance-change losses have reduced considerably the rebalancing and readjusting requirements on grounded telegraph circuits.

Visual Ringing Signal

A new visual signal, recently developed to supplement the audible ringing signal in subscribers' lines, utilizes a cold cathode discharge tube and operates directly from the ringing current without relay or auxiliary power supply. It is more economical both in first cost and in maintenance than any visual signal heretofore available. A metal housing with a glass top protects the tube. The indicator can be mounted against a wall or equipped with a cord and placed on a desk or table. A composition pad on the base minimizes slippage and prevents marring of the surface on which it is placed. This signal can be used in manual, panel, step-by-step or crossbar areas and should find considerable application among subscribers with impaired hearing, and in locations where it is necessary to distinguish between several lines or extensions.

Noise from Shunt Capacitors on Power Systems

By R. M. HAWEKOTTE
Inductive Coördination

DURING the last few years, the extensive use of shunt capacitors for improving power factor and voltage conditions on power-distribution circuits has, in some instances, required that steps be taken to prevent an increase in noise in paralleling telephone circuits. Situations of this sort are being studied as they arise by Project Committee 1A of the Joint Subcommittee on Development and Research, which is composed of representatives of the Edison Electric Institute and the Bell System. In these studies, the committee has had the coöperation of the local power and telephone companies and, in several cases, of the manufacturer of the capacitors. The present article is based upon the results of the committee's work to date.

In themselves, capacitors are not sources of harmonics. When a capacitor is connected to a primary power distribution feeder, however, it may form a resonant circuit at some harmonic frequency with the inductive reactance of the line, voltage regulators, supply transformers, and source of supply, and thus greatly increase the currents caused by harmonic potentials which are present in the system's voltage at or near this resonant frequency.

Typical applications of three-phase shunt capacitors to distribution primaries are illustrated schematically in Figure 1. Depending upon the type of connection, such capacitors may have marked effects on either the "balanced" or "residual" harmonic cur-

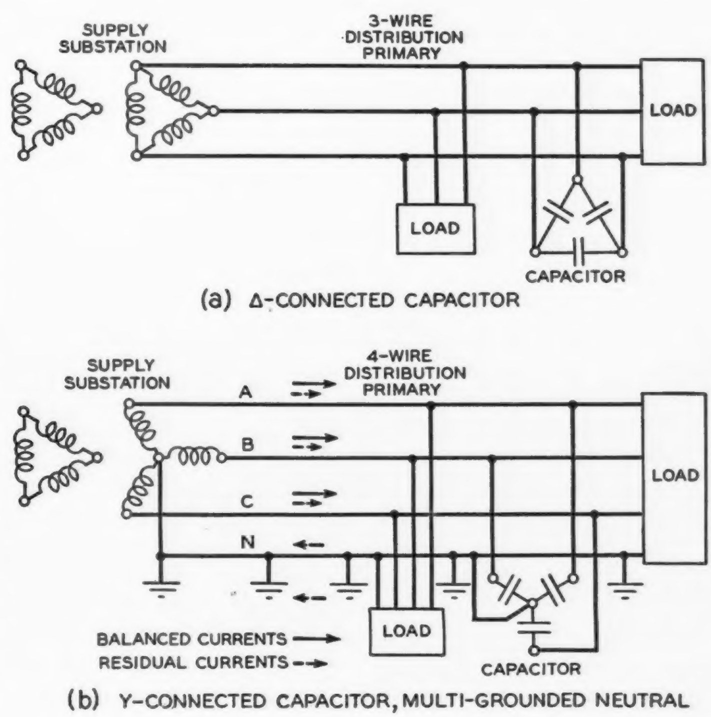


Fig. 1—Three-phase shunt capacitors connected to power circuits may have marked effects on harmonic currents

rents on the circuit or on both. The balanced currents in a power system are those components of the phase currents that are equal and add up vectorially to zero. Thus balanced currents are confined to the phase conductors. Where the phase currents at any frequency do not add up vectorially to zero, their vector sum is termed the residual current. Residual currents flow in a circuit consisting of the three line conductors in parallel as one side and the earth in parallel with any multi-grounded neutral conductors present as the other side, as illustrated in (b) of Figure 1.

The most prominent residual currents are likely to occur at frequencies that are odd multiples of the third harmonic of the fundamental because, at these frequencies, the currents in the three line conductors of a three-phase circuit are in phase and thus add up arithmetically. Residual currents also occur at other frequencies, however, because of inequalities in the phase currents caused by unbalances that may occur in the system, such as unequal loads connected between the phases and neutral of a four-wire circuit or unequal lengths of single-phase branches. About sixty per cent of the residual current in a circuit operating with multi-grounded neutral flows in the earth; the remaining forty per cent returns in the neutral conductor. It is the sixty per cent that returns by way of the ground that has the greatest effect on telephone circuits.

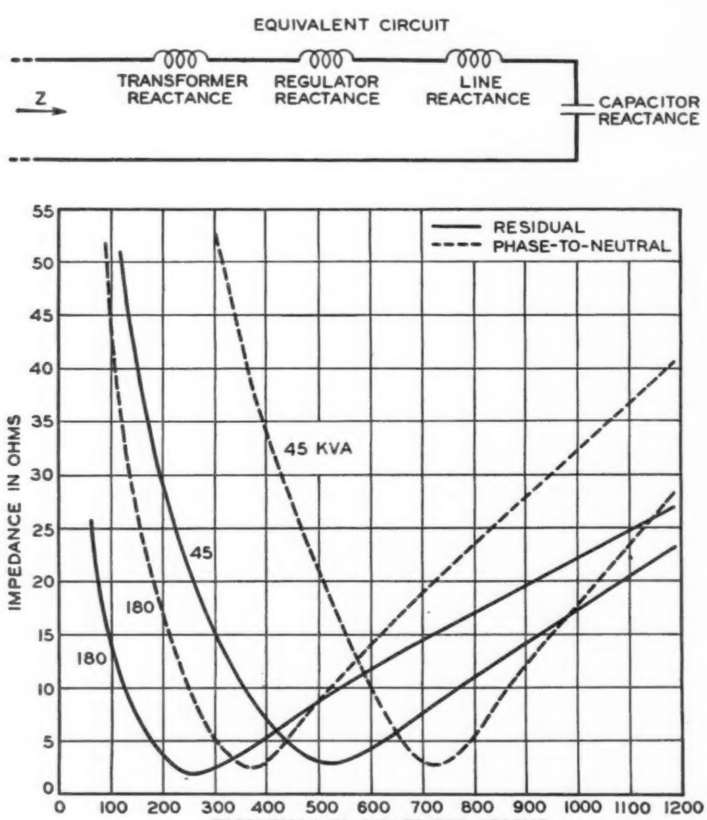


Fig. 2—Equivalent circuit of power system with corrective capacitors, above; and the effects of 45- and 180-kva, three-phase, grounded-Y capacitors on circuit impedances of a two-mile, four-kv line, below

Where three-phase capacitors are associated with the phase conductors only, that is, where they are connected in Δ, as in (a) of Figure 1, or in Y with isolated neutral, they have no effect upon the impedance of the residual circuit and thus can produce resonance in the balanced circuit only. When they are connected in Y with grounded neutral, however, as in (b) of Figure 1, they form a part of both the balanced and residual circuits, and may cause resonance in either or both.

A simple equivalent circuit for a power circuit with a capacitor

connected is shown in the upper part of Figure 2. This type of circuit may be used to represent the phase-to-neutral circuit for computing the effects of the capacitor on balanced harmonic components, or the residual circuit for calculating the effects on residual components. Below this diagram are curves illustrating the effects of 45- and 180-kva, three-phase, Y-connected capacitors on the impedance of the residual and phase-to-neutral circuits of a particular 2-mile, 4-kv line. The magnitudes of the balanced and residual harmonic currents under such conditions depend upon the harmonic potentials present and on the impedances of the balanced and residual circuits, as shown in Figure 2.

Table 1—I·T in Power Circuit Between Substation and Capacitor Location on Three-phase, 4-wire, Multi-Grounded-Neutral Power Circuit

Power System Arrangement	*I·T Product Balanced*	*Residual*
No capacitors	1400	290
Y-connected capacitors with grounded neutral	3500	745
Delta-connected capacitors	3300	295

The inductive influence of a power line current on neighboring telephone lines is determined by its I·T product, which is the product of the current and its telephone influence factor. The effect of a capacitor installation on the I·T product in one particular case involving a three-phase, four-wire power line operated with a multi-grounded neutral is indicated in Table 1. It will be noticed that there was a substantial increase in the I·T product of both balanced and residual currents where Y-connected capacitors with grounded neutral were employed, while the increase was confined to the balanced current for the Δ-connected capacitors. In the balanced circuit, the larger I·T product resulted from an increase in the fifth and seventh harmonic currents, while in the residual circuit, it came from the increase in the third harmonic, or 180-cycle current.

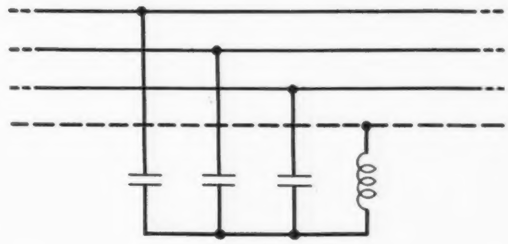


Fig. 3—Capacitor bank with reactor in neutral connection

To what extent this increased I·T product will increase the noise in a telephone circuit depends upon the coupling between the power and telephone lines, the type of telephone circuit involved, and the apparatus with which it is equipped. The effects of the above harmonics on the noise in the receiver of a sidetone-connected station set on an exposed line are indicated in Table 2. With a grounded-ringer set, it will be noticed that the noise was materially increased when the capacitors were connected in grounded

Table 2—Effect of Power Circuit Currents on Noise in Exposed Telephone Circuits

Power Circuit Arrangement	*Noise in Receiver of Sidetone Station Set (Db) Bridged Ringer*	*Grounded 8A Ringer*
No capacitors	Less than 6	21.0
Y-connected capacitors with grounded neutral	6	40.5
Delta-connected capacitors	Less than 6	23.0

Y, but not appreciably affected when they were connected in Δ. With bridged ringer sets, the noise was not important in either case.

The tests indicated that for this particular situation the noise results chiefly from the effects of longitudinal voltages to ground on the telephone circuit, induced by the ground-return components of the residual current in the power circuit. The induced voltages acting on the unbalances to ground in the telephone circuit and equipment produced the noise in the receiver as already described in the RECORD.* With Δ-connected capacitors, the ground-return currents in the power circuit were relatively small, and the induced noise was increased only slightly, while with grounded Y-connected capacitors, there was a relatively low impedance path for the residual current, and the increase in noise was substantial.

There are several measures that may be taken to limit the noise in any given situation. Some of these require modifications in the power system, and others in the telephone system.

*RECORD, *September*, 1939, *p.* 2.

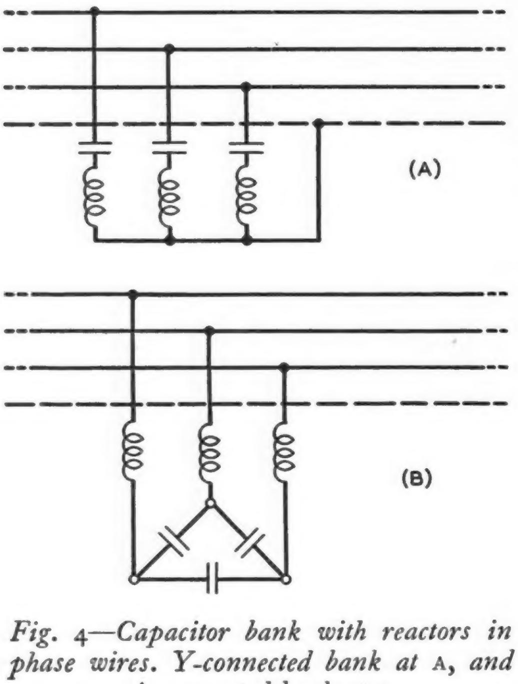


Fig. 4—Capacitor bank with reactors in phase wires. Y-connected bank at A, *and Δ-connected bank at* B

TABLE 3—EFFECT OF NEUTRAL REACTORS ON POWER CIRCUIT INFLUENCE AND TELEPHONE CIRCUIT NOISE

Power Circuit Arrangement	*Power Circuit I·T Product Bal.*	*Resid.*	*Noise in Receiver of Sidetone Station Set with Grounded 8A Ringer (Db)*
No capacitors......	1400	290	21.0
Y-connected capacitors:			
(a) with grounded neutral....	3500	745	40.5
(b) with reactor in grounded neutral....	3000	215	30.0

In the power circuit, where ground-return currents control the inductive effects, Δ-connected capacitors might be employed in place of Y-connected units with grounded neutral. The effectiveness of this measure has already been illustrated in Table 1. A similar effect might be obtained if the neutral of the Y-connected bank were not grounded, but this is not generally desirable because a fault in one of the capacitors might result in high potentials across the other two.

It has been found, however, that a small reactor inserted in the neutral connection is effective in breaking up the resonant condition in the residual circuit. Such an arrangement is indicated in Figure 3. A reactor is usually selected that will form a resonant circuit with the capacitors at 180 cycles. This, of course, prevents resonance with the system at 180 cycles, and above that frequency results in a

net inductive reactance in the residual circuit. A trial of such a reactor was made, and its effect in reducing the I·T product and the noise is indicated in Table 3. This measure does not, of course, affect the balanced components. Furthermore, it does not reduce the residual I·T product to zero, but to a value of the same order of magnitude as with Δ-connected capacitors, Table 1. Although the noise is reduced appreciably from that with the directly grounded capacitors, it is not so low as with the Δ-connected capacitors, as may be seen by comparison with Table 2. With the Δ-connected capacitors the residual I·T product and noise were controlled by frequencies in the range above 540 cycles, while with the Y-connected capacitors and neutral reactor the frequencies below 540 cycles predominated. The greater relative importance of these lower frequencies in the receiver noise, as compared to the residual I·T product, is reflected in the higher receiver noise remaining under the latter condition.

Resonance in the balanced circuit may similarly be prevented by inserting a reactor in series with the capacitor in each phase, as indicated in A of Figure 4. If the capacitors were Δ-connected, the arrangement would be as shown in B. One arrangement of this sort that has been tried experimentally makes use of reactors which resonate with the capacitors in the phase-to-neutral circuit at about 270 cycles. A reactor of this magnitude increases the voltage across the capacitor units by only about 5 per cent, which in most cases is unimportant. If a larger reactor were employed, which would resonate at a lower frequency, the 60-cycle voltage rise would be larger and too close to the operating limits of the capacitor. This arrangement could be combined with a suitable neutral reactor, as indicated in Figure 5, so as to combine the effects of both Figures 3 and 4A, and thus prevent resonance in either the balanced or residual circuits.

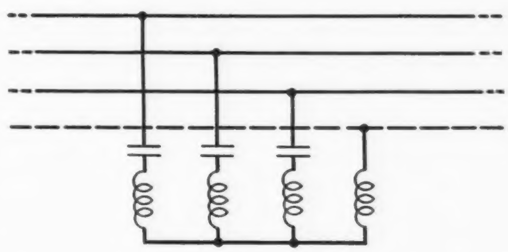


Fig. 5—Capacitor bank with both phase and neutral reactors

There are also several measures applicable to the telephone plant for reducing the noise in situations involving capacitors. As pointed out above, it has been found that the greatest increase in noise on exposed telephone circuits has been that in the receivers of party line station sets, in which the ringer is connected between one line wire and ground. The noise has been found to vary materially with different ringers employed. This is in-

Table 4—Noise in the Receiver of Party Line Station Sets for Several Power Circuit Arrangements

	Noise in Receiver (Db) Y-connected Capacitors on Power Circuit — *With Grounded Neutral*	*With Reactor in Grounded Neutral*
Sidetone Station Set		
8A Ringer	43.5	34.0
8J Ringer*	17.5	8.0
Anti-Sidetone Station Set		
8A Ringer	32.5	22.5
8J Ringer	20.0	10.0

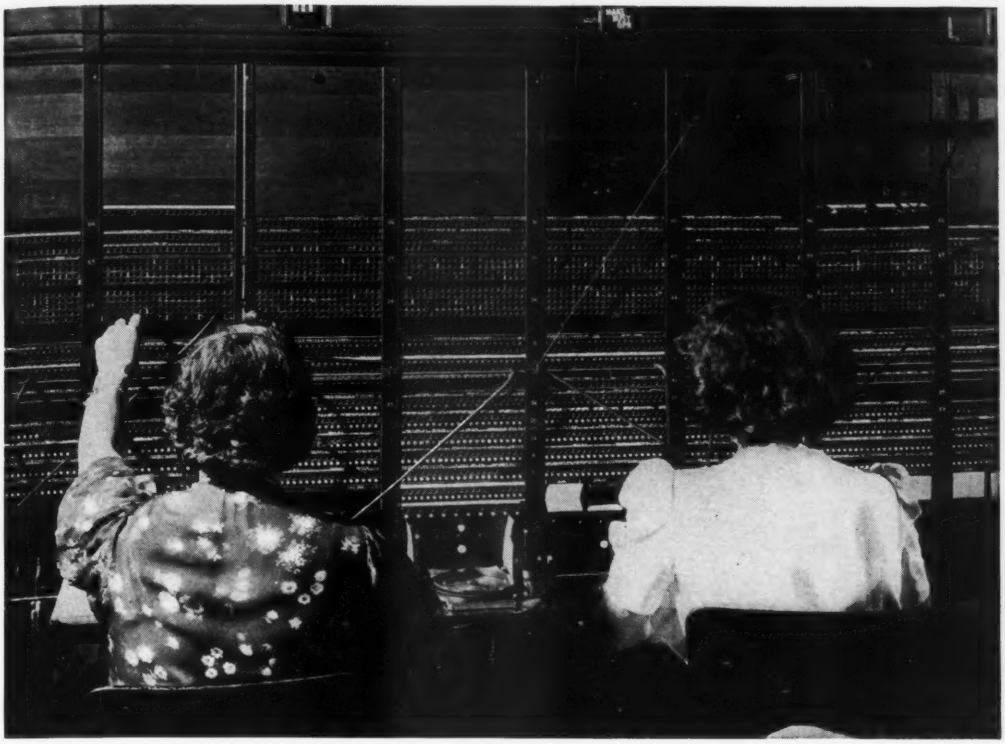
*Double condenser station set

dicated in Table 4. These data are confined to measurements on a set equipped with a 337 transmitter and 144 receiver, since the noise-weighting factors for the newer types are still under development. The results indicate that material reductions in receiver noise may be obtained either by converting sidetone sets with the lower-impedance 8A ringer to anti-sidetone sets with the same ringer or, preferably, with the 8J ringer. Other measures applicable in the telephone plant to reduce the effects of longitudinal induction have been discussed in detail in the article already referred to. These include cable-sheath shielding, longitudinal chokes, and drainage circuits.

Where the exposed telephone circuits are of open-wire construction, coördinated transpositions offer a means of noise reduction where the direct-metallic induction is an important contributor. This measure, for example, would be most effective on toll circuits, which are well balanced, and on subscriber circuits equipped with bridged ringers or with grounded ringers of the higher impedance type. Where numerous discontinuities are present, however, the effectiveness of telephone transpositions is reduced.

It is evident from the foregoing discussion that there are a number of factors involved in noise coördination problems resulting from installations of power system capacitors. The measures appropriate for any specific case will depend upon the circumstances surrounding that situation, there being no unique or universal solution yet available for coördination problems of this type. In the cases thus far studied, the solutions have involved the application of measures to both the power and telephone systems singly and in combination.

G. W. Galbavy determines the pulling characteristics of a holding magnet of a crossbar switch vertical unit



An Answering-Time Recorder

By H. G. W. BROWN
Switching Development Department

THE interval of time between the origination of a telephone call and the operator's answer is called the "answering time." Since this interval is one criterion of the service given by a central office, it should be kept as small as is consistent with economical operation. Answering time depends on a number of factors such as the size and proficiency of the operating force and, in certain types of office, on the proper distribution along the switchboard of the lines of various calling rates. The rate at which calls come into the board, and thus the number of operators required to answer them properly, varies from hour to hour and from season to season. One of the important tasks of the supervisory force is to see that the number of operators at the board is adequate for the calling load at all times. Long experience has proved that the most satisfactory and economical service is given when the average answering time is kept constant throughout the day and year.

Studies made at each office show the variation in load both in its daily cycles and in its seasonal trends, and this information furnishes data for arranging the schedules of the operating force. To ensure that the schedules are satisfactory, it is desirable to obtain records of the answering time, and to provide such records an

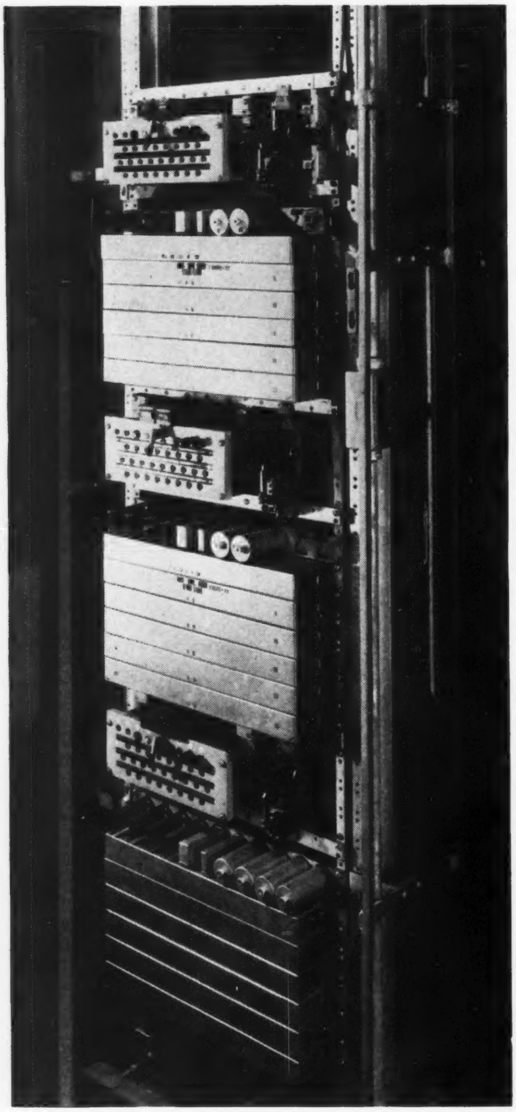


Fig. 1—Three answering-time recorders in the Long Lines building in New York City

answering-time recorder has recently been developed. It is designed for use with manual switchboards, dial system "A" boards, toll boards, or such auxiliary and miscellaneous equipments as intercepting and information desks.

The new instrument makes a record of the total number of calls handled by the recorder and the number of these calls that were not answered within a specified time. It is arranged for connection to twenty-five lines, and the lines associated with it at any one time may be distributed over an entire switchboard, so as to give a representative sample of the service at the board, or they may be confined within narrower limits, as occasion may indicate desirable.

Fundamentally the recorder consists of two electrically operated registers with the necessary connecting and control relays. One is known as the total-calls register, and operates each time a call obtains control of the circuit. The other is known as the delayed-answer register, and operates each time an observed call is not answered within the time for which the recorder is set. The indications of these registers are read periodically. If, for example, the readings are taken

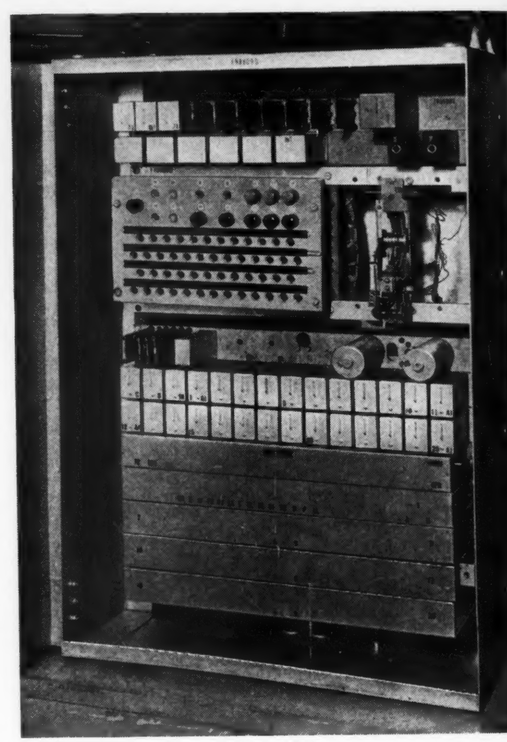


Fig. 2—An answering-time recorder in portable form installed in the "information" office at Paterson, New Jersey

every hour of the day, or every half hour as is done in some places, a complete record is available of the variations that occur in the answering times during both light and heavy load periods.

When a call comes in on one of the lines connected to the recorder, a series of relays operate. These first operate the total-calls register, and then arrange the circuit so that subsequent "flashing" by the subscriber will not cause false operation of the register. They then connect a lead from the 120 i.p.m. office interrupter to a rotary selector, which acts as a counting mechanism. It moves ahead one step on each pulse from the interrupter and operates the delayed-answer register on reaching a step that corresponds to the delay time to be measured. The recorders are arranged to count time intervals of almost any duration up to 20 seconds with a maximum deviation on any one observation of +0.5 second. Any type of interrupter available in the office may be used; when the interrupter lead is closed, the magnet of the selector is operated, and when the interrupter lead is opened, the armature of the selector advances the brush one step as the armature releases.

Fig. 3—The "total-calls" and "delayed-answer" registers used with the portable unit are installed in a separate box in the operating room

If the call is answered before the delayed-answer register has been operated, the selector is advanced to the normal position, all operated relays are released, and the circuit is made available for the next call. The circuit similarly releases and restores to normal after the delayed-answer register has been operated. The equipment is thus never held on a single call longer than the delayed-answer period.

As already noted, the recorder is accessible to twenty-five lines, but the answering time can be measured on only one line at a time. A chain of relays is therefore provided so that while one call is being timed, all the other lines are excluded from the register. A further precaution is taken to prevent the recorder from timing calls which might have started while it was busy. Hence not all calls originated on the twenty-five lines are timed, but the result has been found to give a fair sample of the answering time on the group of lines that are being observed.

The recorder is arranged in two forms: one for permanent mounting on a relay-rack, and one in a small cabinet for portable use. An installation of three recorders of the former type at the Long Lines building in New York City is shown in Figure 1. The "chain" and other relays are on the lower part of the unit, and the selector that does the timing is at the upper right. The jacks are used primarily for testing purposes. When recorders are installed in a large office, where there are many trunk groups to be studied, a switching arrangement is provided that enables the recorder to be transferred from one group to another as desired. This circuit is operated by a small dial switch, which permits as many as ten groups of trunks to be associated with the recorder one at a time. This switch, installed just above the multiple on one of the switchboard lines at the Long Lines building in New York City, is shown in the photograph at the head of this article.

A portable unit, installed at the "information" office in Paterson, New Jersey, is shown in Figure 2. There are slight differences in equipment and arrangement of the two forms because of the differences in the type of service, but all the main features are the same. In either form, the use of the recorders materially reduces the effort required to obtain answering time data, and the equipment greatly increases the quantity of data obtained in an equal observing interval.

In this life test for telephone booth treads, leather and metal flaps attached to a rotating drum simulate the scuffing action of shoe leather and nails. The treads, attached to the front and back vertical members of the frame, are being inspected by W. A. Krueger

Contributors to this Issue

R. M. Hawekotte graduated from Purdue University in 1924 with a B.S.E.E. degree, and at once joined the Department of Development and Research of the A. T. and T. He was engaged chiefly in the development of special measuring apparatus used in tests on inductive interference, and in investigations of inductive coördination problems involving voice-frequency noise on telephone circuits resulting from wave-shape distortion on power circuits. He has also studied frequency-selective devices applicable to the power system as a means of correcting the wave-shape distortion. In 1934, with the D & R, he transferred to the Laboratories where he has continued inductive coördination studies. A considerable amount of this work was with the Joint Subcommittee on Development and Research of the Bell System and Edison Electric Institute.

K. L. King graduated from the State College of Washington in 1929, and soon after joined the Radio Research Department of these Laboratories. Since then he has been engaged primarily in the development of radio equipment. At first he assisted in the development of transmitters for ship-to-shore service, and then took part in the design of the first single-sideband transmitter for transoceanic short-wave telephone communication. He later went to England for an extensive series of tests of this new transmitter, and has since worked on the various designs leading up to the transmitter described in this issue.

Allan Weaver was graduated from the University of Nebraska in 1921 with the degree of B.Sc. in E.E. He joined the Department of Development and Research of the A. T. and T. that year to work on the engineering requirements and the design of direct-current telegraph repeaters. For five years beginning in 1924 he was concerned with the engineering requirements of telephotograph systems. Since 1929 Mr. Weaver has worked on teletypewriters and associated repeater equipment. In 1934 he transferred to the Laboratories with the D & R.

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as night operator, but later transferred to central-office maintenance work. His ability and wide experience in this field led to his transfer to the Engineering Department of the Western Electric Company in 1920. Here he engaged in laboratory testing and circuit design. With what is now the Switching Development Department he has engaged in a wide variety of activities, concerned primarily with manual switchboards and their associated and auxiliary circuits.

H. H. Felder was graduated from Clemson A. and M. College in 1918 with a B.S. degree in electrical and mechanical engineering. After some months in the U. S. Signal Corps he joined the Engineering Department of the A. T. and T. in January, 1919, and became a member of the Department of Development and Research upon its formation later that year. He has been engaged in general transmission problems in connection with telephone repeater development and toll circuit layout and switching. Recently he has been engaged also in work on some of the phases of cable loading as applied to entrance cables for type-J open-wire carrier systems.

D. F. Johnston received the B.S. degree in electrical engineering from The Catholic University of America in 1922, and at once joined the Technical Staff of these Laboratories. With the Systems Development Department he at first associated with the method-of-operation group, but later transferred to the panel switching laboratory, and still later worked on the design of circuits for local test desks. In more recent years, he has devoted his time to the design of circuits for toll switchboards.